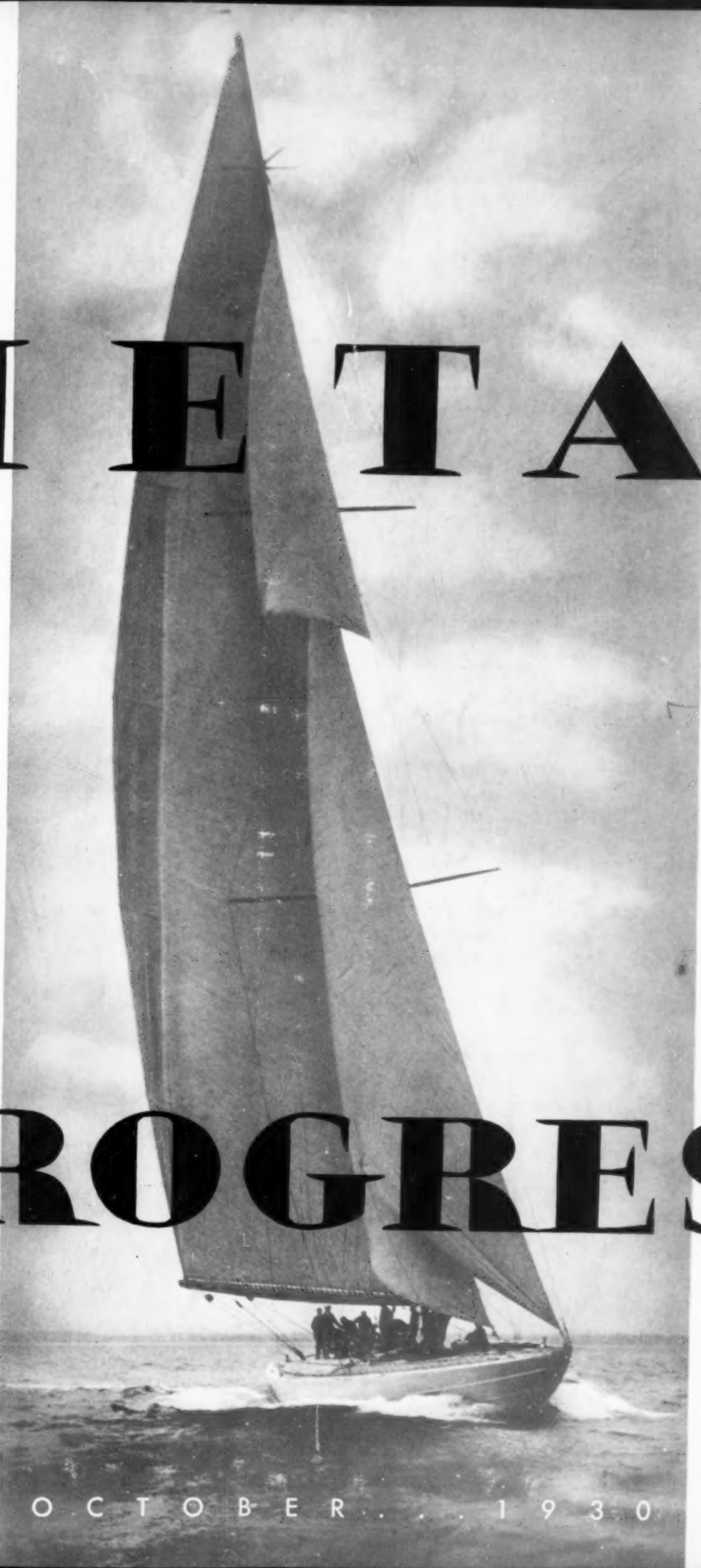
METAL PROGRESS



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Metal Progress

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Ernest E. Thum, Editor

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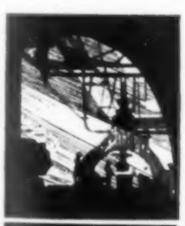


Steels used for fine Springs

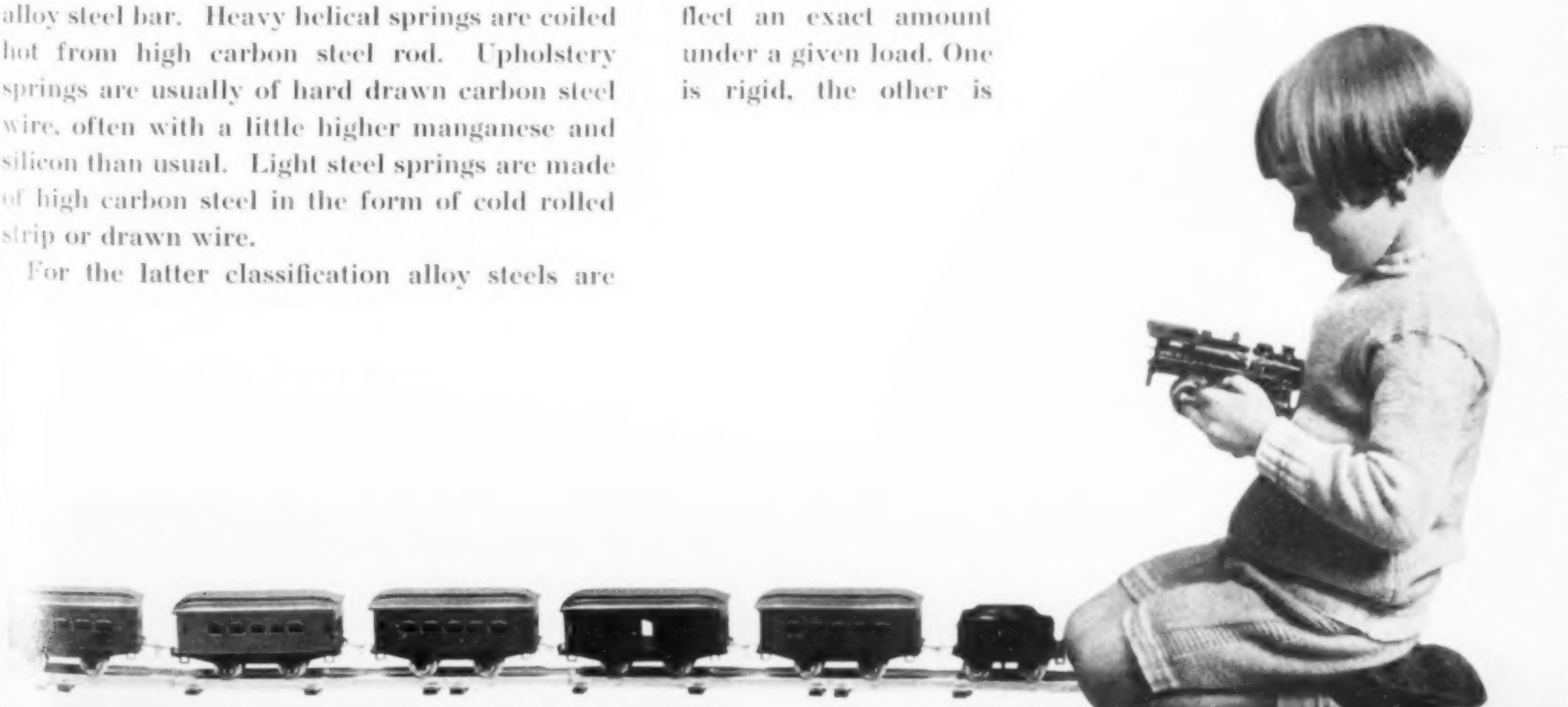
SPRING engineering and manufacturing is a highly specialized business, since springs are made in an infinite variety of sizes and forms, ranging from the tiny hair spring in a lady's wrist watch to a stiff coil under a locomotive journal or a combination of leaf springs supporting a 5-ton truck. It is only natural that various firms should specialize in certain branches of this field, for the manufacturing equipment used is almost as various as the size and shape of the finished product.

A convenient classification of the industry may be made as follows: Leaf springs (for vehicles); Heavy helical springs (to work in compression); Upholstery springs; Fine springs made of wire or thin strip. Some specialties may not fall clearly in one or another group of this rough outline, but nevertheless it will include most of them made today.

It is also true that the steels going into the different types of springs are more or less characteristic. Leaf springs are commonly made of alloy steel bar. Heavy helical springs are coiled hot from high carbon steel rod. Upholstery springs are usually of hard drawn carbon steel wire, often with a little higher manganese and silicon than usual. Light steel springs are made of high carbon steel in the form of cold rolled strip or drawn wire.

For the latter classification alloy steels are seldom used, because very high physical properties can be given to small diameter wire or thin strip by the proper combination of carbon content, cold work and heat treatment, and the result is apparently more reliable and uniform than can be readily achieved by the alloys now on the market. Certain exceptions to the above statement may be noted for springs working at moderate temperature, or in a corrosive atmosphere, or which must have definite electrical characteristics.

It is not commonly known that plain carbon steel in small sections can be given such an extraordinary combination of strength and toughness. In fact, the whole subject of spring engineering is mysterious to most engineers. This is understandable. They ordinarily design and build rigid structures and machine parts. A roller bearing, for instance, must resist appreciable deformation at working loads; a spring, on the other hand, is designed to deflect an exact amount under a given load. One is rigid, the other is



Much Hand Work is Done In Coiling Highest Grade Springs. After coiling, motor springs are held in a stiff wire "keeper" until mounted in the mechanism in which they will be used.

pliable; both may be made of hardened alloy steel. It seems to be a paradox!

That is not the only fact about springs that is little known. Old timers in the railroad industry remember the rubber blocks used for springs in the truck bolsters. Younger men of inquiring mind will find interesting reading in William Metcalf's paper on "Springs and Spring Steels" presented before the American Society for Testing Materials in 1903, wherein he pungently recounts how plausible salesmen and patentees exploited almost every conceivable shape of rod as the best steel section for making car springs. Almost a new generation was necessary before it was generally accepted as a proven fact that a round rod gives the best disposition of metal to resist the torsional stresses of a compression spring in service.

We can congratulate ourselves that spring engineering has progressed to a point where the shapes of wire, bar or strip used will be selected so that the metal will be used to best advantage and the stresses distributed as uniformly as possible.

For instance, helical compression or extension springs are of round wire or rod, since the greatest stresses induced by the working loads are torsional in nature, and a round cross section like a shaft is the best shape to resist torsion. Spiral or involute springs for the storage of power, such as clock and watch main springs and motor springs for driving phonographs or mechanical toys, are of thin strip, to absorb bending strains without damaging concentrations of stress. Elliptical or leaf springs for vehicle suspensions are bars, to work best as simple or cantilever beams. Torsional helixes for absorbing twists, like springs in door checks, or shock cushioners on shaft couplings and Bendix starters are rectangular — again to resist bending.

The above facts, of course, are among the most elementary in spring engineering, yet are not well enough known to the buyers and users of springs. Another fact that leads many consumers astray is that the loading characteristics of a steel spring depend entirely on its shape and dimensions, and cannot be modified by tempering, alloying, or heat treatment.

Stated in another way: Suppose a hundred different pieces of 0.135-in. steel wire, some low carbon, some medium carbon, high carbon, low alloy, high alloy, each analysis heat treated in several different ways, were coiled into a helix,

...y of 1.2 in. outside diameter, 3.4 turns per inch and cut off exactly 6.6 in. long. Then if a 1-lb. weight were placed on each of these springs, each would shorten the same length, (0.05 in.) and each would recover the original height when the load were taken away. The softest iron wire is equivalent to the hardest steel in this respect, when it is loaded to less than its elastic limit.

A little reflection shows why this is so. The compression of a helical spring under load is a measure of its modulus of elasticity. Modulus of elasticity is the ratio of the stress by the strain (as books on mechanics define it). Worded in other ways, the meaning is this: Up to the elastic limit, the modulus of elasticity of any metal is a constant value; the proportion between the load on the test piece and its measured extension is the same; the first part of the stress-strain curve plots as a straight line. If the above springs deflect 0.05 in. for 1 lb., each will deflect exactly twice as far, or 0.10 in., when a 2-lb. weight is carried, simply because the modulus of elasticity of steel is substantially independent of its carbon and alloy content, its hardness, its heat treatment, or its method of manufacture.

The above statement should be made with certain qualifications. The modulus of elasticity of steel has an annoying way of coming out as a slightly different figure when consecutive tests are made, even with the greatest accuracy. It is not something we can be dogmatic about, like the statement that a cubic foot of pure water at standard temperature and pressure weighs 62.4283 lb. at the sea level. The modulus of steel will figure to some value between 27,000,000 and 29,000,000 for soft steels, ranging up to 30,000,000 to 32,000,000 for hardest carbon and alloy steels. Designers generally use the figure 30,000,000 as representing an average of the hard steels used in springs.

Since the modulus is constant, the loading characteristics of a steel spring depend entirely on its dimensions, and cannot be modified by tempering or heat treatment. If the above spring were too stiff for the purpose intended, the only way to increase the flexibility would be to decrease the diameter of the wire, to increase the number of coils per inch, or to increase the diameter of the coil, or by some appropriate dimensional combination. If, by some freak in the design, none of the dimensions could be changed, a too-stiff steel spring would have to be constructed of some other alloy. These would give more flexible springs, since flexibility would vary as the modulus of elasticity for the various materials, as follows:

Hard steel	30,000,000
Monel metal (Ni 70, Cu 30) ...	26,000,000
German silver (Cu 55, Zn 27, Ni 18)	20,000,000
Spring brass (Cu 72, Zn 28) ...	14,500,000
Phosphor bronze (Cu 92, Sn 8)	14,000,000

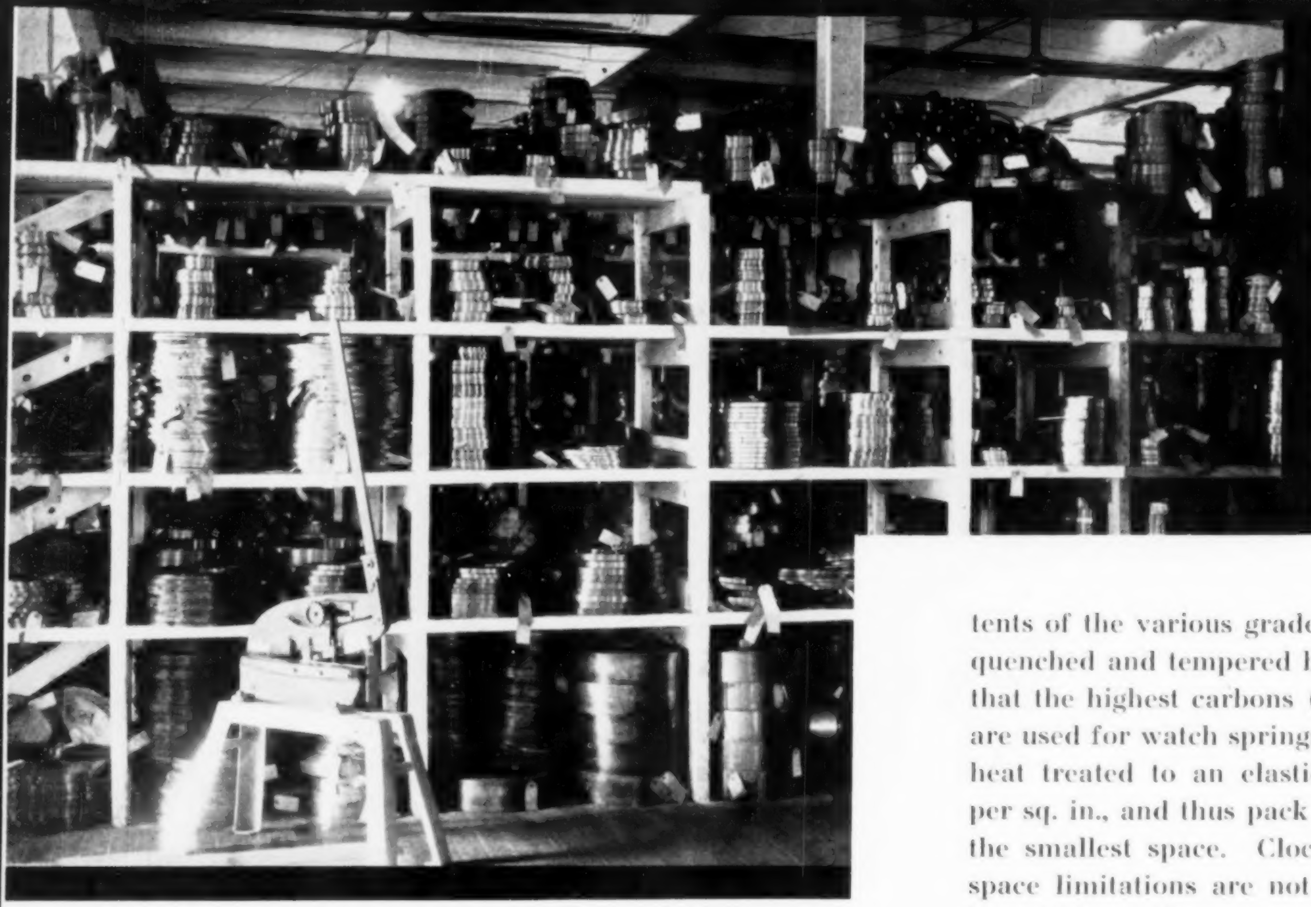
If, then, the load characteristics of a spring are independent of its temper, why are all springs made of hard steel? Simply because the metal in a spring at working loads is carrying high stresses, and these stresses must not pass the elastic limit, else the spring will acquire a permanent set and fail to return to its original shape if unloaded, or fail to deliver the proper "push" when compressed. A coil of softest iron wire will act as a true spring under very mild loads; a similar spring of high carbon wire will rebound under loads 11 times as heavy — the elastic limit of the one is 30,000 lb. per sq. in., of the other may be as high as 330,000. But it is quite possible to give either variety of spring a permanent set by overloading; under further overloads they may break.

Spring Material All Cold Worked

Obviously, then, the way to economize on material is to put into a spring the strongest steel available. Here is where the advice of an expert spring-maker is desirable, for there is a balance between the rising cost of very fine spring steel and the rising weight of the coarser varieties of steel. It would be silly to make upholstery springs, for instance, of steel suitable for airplane engine valves.

Passing without comment the alloys used in vehicle and heavy coiled springs, the high strength, high carbon steels used for fine springs in the Wallace Barnes plant, Bristol, Conn., vary widely in methods of manufacture. Dimensions of the stock material — diameter of wire, width and thickness of the strip — will vary as well. Consequently the warehouse serving the spring making department is a succession of aisles such as shown on the top of the following page.

The first general classification, namely, strip



and thin bars, is cold rolled to correct size with many intermediate process anneals, and then heat treated to high strength and hardness either before forming or after forming into a spring, depending upon the sharpness of the required bends in the finished piece, or the amount of stamping or cutting which is necessary in fabrication. Sometimes, as in the manufacture of phonograph springs, the quenched and drawn strip is cut to length and the very end softened enough for a sharp bend. Then the spring is wound by hand, as shown on page 34, and a "keeper" slipped over it until assembled in the intended device.

Wire, the second general classification of material, is all cold drawn, either by the soft process (drawn from annealed rod) or by the hard process (drawn from patented rod). Any desired ductility suitable for sharp bends during forming can be secured in such wire by proper tempering, either in process or after the final draft. Springs made of annealed wire must be heat treated after forming, but this is to be avoided in springs made of small diameter wire, on account of the liability of roughening the surface by furnace scale, and the fact that it is impossible to heat treat small parts to the same degree of uniformity that it is possible to give to a wire by drawing it endwise through long lead baths.

Considering now the tempers or carbon contents of the various grades of cold rolled strip, quenched and tempered before coiling, we find that the highest carbons (1.15 to 1.25 per cent) are used for watch springs, because they can be heat treated to an elastic limit of 330,000 lb. per sq. in., and thus pack the highest energy in the smallest space. Clock springs, where the space limitations are not so stringent, usually have 0.90 to 1.05 per cent carbon. Motor springs for phonographs and mechanical toys are the next grade down — 0.80 to 0.90 per cent carbon. Shock absorbers and trolley rope rewinders are ordinarily made of much huskier sections and are not stressed so highly in service; nevertheless they must be carefully made of steel strip containing 0.90 to 1.05 per cent carbon to avoid breakage in service. Much might be said about the relationship between elastic limit, maximum working stress and expected life, but that would form the subject of another article. Suffice it to say that a spring maker could easily make a main spring for a watch which would not break in 100 years, if the watch users would not insist on buying the smallest and the thinnest models on the market.

As remarked above, annealed strip is used where sharp bends are necessary. For instance, an infinite variety of springs to hold the carbon brushes against electric generator or motor armatures are made of thicker strip or flattened wire of 0.90 to 1.05 carbon steel. These are manufactured to close specifications as to size and loading characteristics. Ordinarily they are coiled with a leather thong between each turn, so that the spacing is exact. After quenching, tempering and cleaning they are given 100 per cent inspection under the specified load, as shown on the last page of this article.

Lower carbon annealed strip (0.70 to 0.80 per cent carbon) is pre-eminently a flat spring material, for making such things as clips and snaps

to hold down covers, spring washers, and springs for door hardware and padlocks. It will cut, bend and form easily on high speed presses, and after manufacture would be quenched and drawn to an elastic limit of about 200,000 lb. per sq. in.

Cold Drawn Wire Makes Tiny Springs

Wire is also utilized in more than one carbon for making springs.

Music wire is the highest grade. It is ordinarily electric steel with carbon 0.80 to 0.90, patented and cold drawn. Its strength depends on the amount of reduction between the last process anneal and the final size; ordinarily the smallest wires are strongest. Wire 0.015 in. diameter has an ultimate of approximately 400,000 lb. per sq. in.; 0.062 in. wire 300,000.

Such wire does not have an easily determined elastic limit; it is assumed to be about 60 per cent of the ultimate tensile strength. Recent investigations by L. S. Moisseiff on bridge wire 0.192 in. diameter (high carbon steel, patented and cold drawn to a minimum of 215,000 lb. per sq. in. tensile strength), showed that its proportional limit and the load at which first set occurs are practically identical at 103,000 lb. per sq. in., which is about 47 per cent of the ultimate.

For the reason that small permanent sets will occur if the spring is overloaded, music wire springs will change in length slightly if worked at unduly high stresses, but the wire is so exceedingly tough that they seldom if ever break. The material is also highly uniform, and the good properties are inherent to the method of fabrication. Consequently, music wire will be the preferred material for helical springs of small size, say 0.10 in. wire diameter down to 0.005 in., which require toughness, or maximum uniformity.

Illustrations In This Article Were Obtained Through the Courtesy of Wallace Barnes Co., Bristol, Conn. In this plant, specializing in the manufacture of fine small springs, may be observed the practices described in this article. While some springs, like those for Bendix starters, are made in such quantity that fully automatic machinery can be used, most of the items produced by Wallace Barnes are of a size and variety which require an unusually high percentage of craftsmen's labor, both in the manufacture and inspection.

Inexpensive helical springs of moderate strength, made of somewhat larger wire (say 0.06 in. diameter and larger) would use "hard drawn spring wire," a patented and cold drawn material containing 0.50 to 0.60 per cent carbon, and manganese up to 1 per cent added to increase the strength and chemical uniformity.

While cold drawn wire is tough enough to curl into a pigtail, it cannot take a square bend. For springs requiring such drastic forming, or for springs requiring wire of diameters, say 0.25 in. and larger, an annealed wire would be used, which would be quenched and tempered after forming. Two analyses are commonly used; so-called "annealed high carbon wire" approximately corresponds in chemistry to music wire, and "oil tempered wire" corresponds to hard drawn spring wire. The first makes scale springs and the other classes of high grade wire springs, especially in coarse sizes, and the latter analysis is used for the general run of spiral springs, not too small. Heat treated wire has a much higher elastic limit for a given ultimate strength than hard drawn wire; consequently, a spring which must recover its shape exactly even after heavy load, like a scale spring, would be made of heat treated wire.

How a Discovery has been Commercialized

Progress in Nitriding

NITRIDING on a practical and commercial basis may be said to have its beginning in the year 1923. Dr. Fry of the Krupp works, Essen, Germany, in that year obtained patents both on the nitriding process and on some special nitriding steels. Certainly these discoveries will be classed among the marked achievements of this mechanical age.

Previous to Dr. Fry's work but little was known regarding the behavior of nitrogen toward iron; nevertheless earlier work must have been very helpful. Therefore, a brief account of it will not be amiss.

In 1888 Tolander printed a paper in *Stahl und Eisen* on the injurious effect of nitrogen on the physical properties of iron. In the same publication in 1906, Braune gave the first detailed and scientific work on these effects, saying "Complete neglect of the presence of nitrogen in metal probably will not continue long."

Efforts were made to prepare iron-nitrogen alloys by introducing nitrogen or ammonia gas into molten iron. Strauss (1914) and Sawyer (1923) attempted this at low and ordinary pressures and Andrews (1912) investigated the method at 200 atmospheres pressure. Their efforts, however, were unsuccessful, as may be found by consulting their publications in *Stahl und Eisen*, *Transactions* of the American Institute of Mining Engineers and the *Journal* of the British Iron and Steel Institute, respectively.

Nitrogen was readily introduced into solid iron by diffusion. The usual method was to heat finely divided iron at 1100 to 1300 deg. Fahr. in a stream of ammonia. A content of 11.1 per cent nitrogen, corresponding to the formula Fe_2N, is thus obtained. Other compositions of iron nitride were reported; Wurtz' dictionary gives the formulæ Fe_5N_2, Fe_6N_2 and Fe_4N_2. Whether these were mixtures of one or more nitrides with excess iron had not been established.

It was known that either iron or nitrogen must be in the nascent state to combine. Iron submitted at red heat to ammonia becomes brittle and white and may increase in weight 13 per cent. Reduced to a powder, the iron nitride burns brilliantly. When heated to a high temperature, either in air, nitrogen or ammonia, it gradually loses its nitrogen; heated in hydrogen, it gives metallic iron and ammonia.

Such fragmentary knowledge must have led Dr. Fry to study the iron-nitrogen system first. Later he investigated the effects of combining nitrogen at various temperatures with many metallic elements. He found that aluminum, vanadium, chromium, molybdenum, manganese, titanium and tungsten readily combined with

By **Robert Sergeson**

nitrogen when exposed to action of ammonia gas at certain temperatures.

Aluminum appeared to have the greatest affinity for nitrogen, and the nitride is very stable, no decomposition taking place up to 1800 deg. Fahr. Dr. Fry then produced steels containing these various elements separately and in combinations and subjected them to the action of ammonia gas at relatively low temperatures with the results now so well known.

Early Commercial Handicaps

While a number of alloy combinations must have showed promise, Dr. Fry selected for his first commercial nitriding steels the aluminum-chromium steels with various carbons. This series was tried in Europe successfully; in 1926 they were first described in the United States at the convention of the American Society for Steel Treating, but the process made little progress in this country before 1929 for the following reasons:

1. The steels were high in price and made in small lots in the electric furnace.

2. Chromium and aluminum content was relatively high, both ranging from 1.3 to 1.8 per cent, which meant increased difficulty in manufacturing, processing, and machining.

3. Nickel steels proved unsuccessful, owing to the temper brittleness caused by the long heating at the nitriding temperature. Molybdenum was then substituted for nickel and found to add toughness and give freedom from temper brittleness. This information was not available to the trade until 1929.

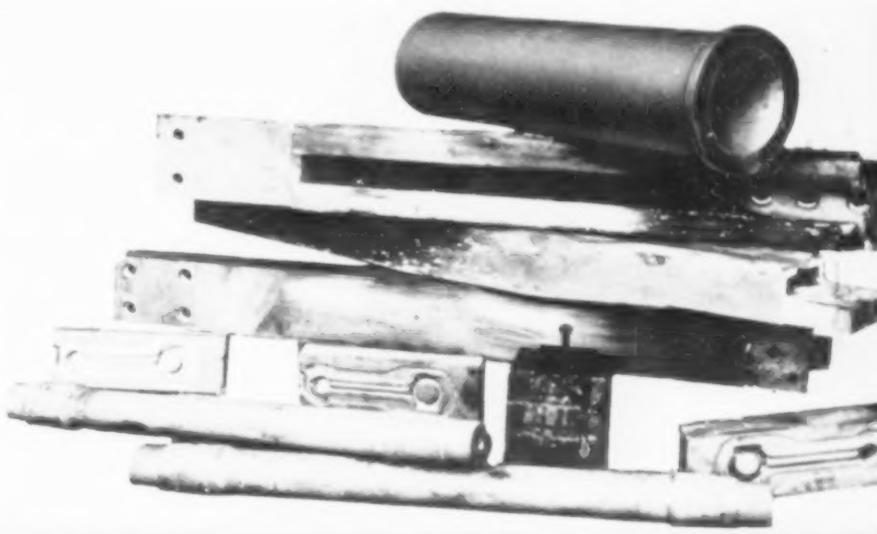
4. Temperatures for heat treating were not well known, and the brittleness of a nitrided decarburized surface was little understood.

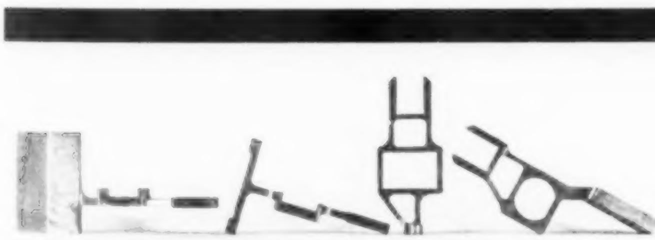
5. It was necessary to build one's own furnace, since there were no companies selling complete nitriding equipment.

6. Nitriding containers were sealed by an asbestos gasket and no mechanical means for circulating the gas was provided. Considerable trouble, especially with larger containers, was encountered in keeping a gas-tight joint. The container was made of carbon steel or chromium-nickel-iron alloy (18-8) and these were not entirely satisfactory. Whether circulation of the ammonia was required for uniform results was questionable.

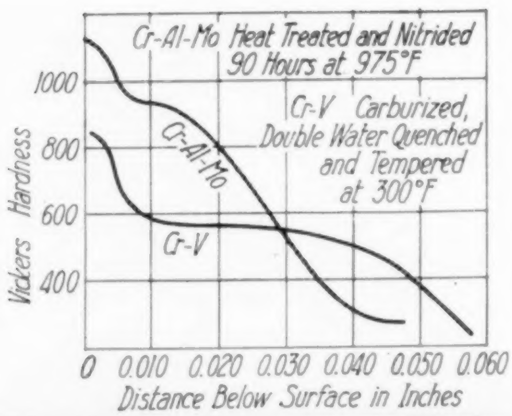
7. Applications of nitrided parts under various types of service were still under test.

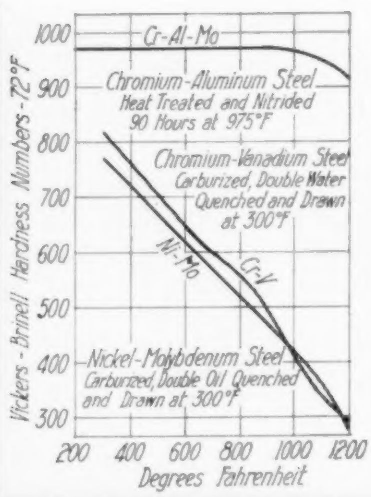
From the early part of 1929 to the present writing, nitriding has had a steady and very healthy growth. The reasons for this are summarized in the following paragraphs.





Articles of Extreme Size, Both Large and Small, Now Nitrided in Commercial Practice. Contrast the small intricate parts for a movietone camera, as shown below, to the massive locomotive parts pictured at the right. Two piston rods are on the floor, and resting on the forging dies for a small connecting rod are three cross-head guides. These are very difficult to carburize and harden in the old manner without sagging, warping, or bulging the machined bearing surfaces.

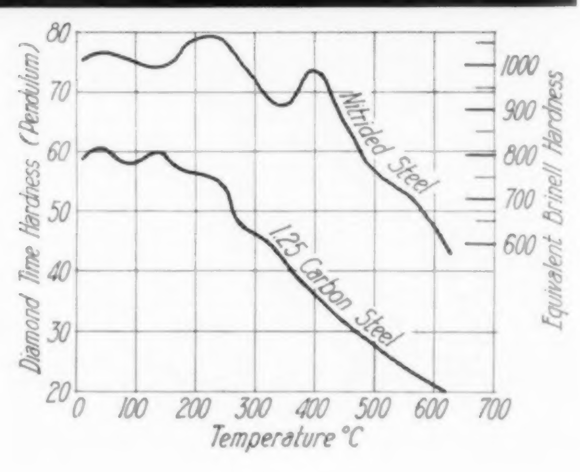




Upper Diagram Gives the Relation Between Hardness and Depth of two Commercial Steels After Nitriding.

In the Center are Curves Showing that Chromium-Aluminum - Molybdenum Steel Retains All Its Surface Hardness Even After Heating to 1000 deg. Fahr.

Hardness at Elevated Temperatures is Shown in the Lower Curve. Nitrided steel is still hard even when operating at 400 deg. C.



It was learned late in 1928 that the chromium and aluminum could be lowered to 0.8 to 1.3 and 0.6 to 1.2 per cent respectively without any appreciable hardness loss. Molybdenum of 0.15 to 0.25 per cent was satisfactory. This lower alloy content aided in the manufacture and handling of the steel.

It was also proven that these steels could be made in the open-hearth furnace under routine production conditions which necessarily lowered the cost and market price. A nitriding analysis containing 1 to $1\frac{1}{2}$ per cent aluminum and $\frac{1}{2}$ to 1 per cent molybdenum also entered the market at this time, thus further increasing the interest in commercial applications of nitriding.

Proper temperatures for heat treating to a more uniform product were investigated. It became known that a quenched and drawn steel produced a hard tough case, while a normalized, annealed or as-rolled steel gave a relatively brittle case.

At this time many furnace builders designed nitriding equipment, and such is now available from various sources. Also many plants have been equipped for commercial nitriding.

Many improvements have been made in the containers. The asbestos seal is now seldom used, being replaced with low melting alloys, such as the tin-lead eutectic, lead, or Rose metal, or by oil. Finely divided chrome ore (150 mesh), in a layer 3 in. deep, has proven to be a successful seal in experimental furnaces. Plain carbon and stainless iron containers with their inside surfaces enameled are showing excellent results. Circulation of the ammonia has proven to be desirable for obtaining uniform temperature and surface results.

The effects of temperature are better understood. The higher the nitriding temperature is, the lower the hardness and the deeper the penetration. If a soft case is obtained at 1050 to 1200 deg. Fahr., it cannot be hardened by a subsequent nitriding at a lower temperature. Brittleness of the case may be greatly reduced without material loss in hardness by subjecting the nitrided parts to temperatures of 1175 to 1200 deg. Fahr. for a short time under iron filings or charcoal.

The duplex method of nitriding for the required number of hours at the low temperature

(950 to 975 deg. Fahr.), followed by raising the temperature to 1175 for one to four hours has given excellent surface hardness (1000 Vickers Brinell) with no brittleness. Care, however, must be taken to support sections properly, lest they warp at the higher temperature.

Finally, many applications have been tested and approved.

Why is the nitrided surface surely forcing its way into our industrial market, in valves, machine parts, automobiles, airplanes, locomotives and gas engines? Perhaps the best answer to this is to review the properties of this nitrided case.

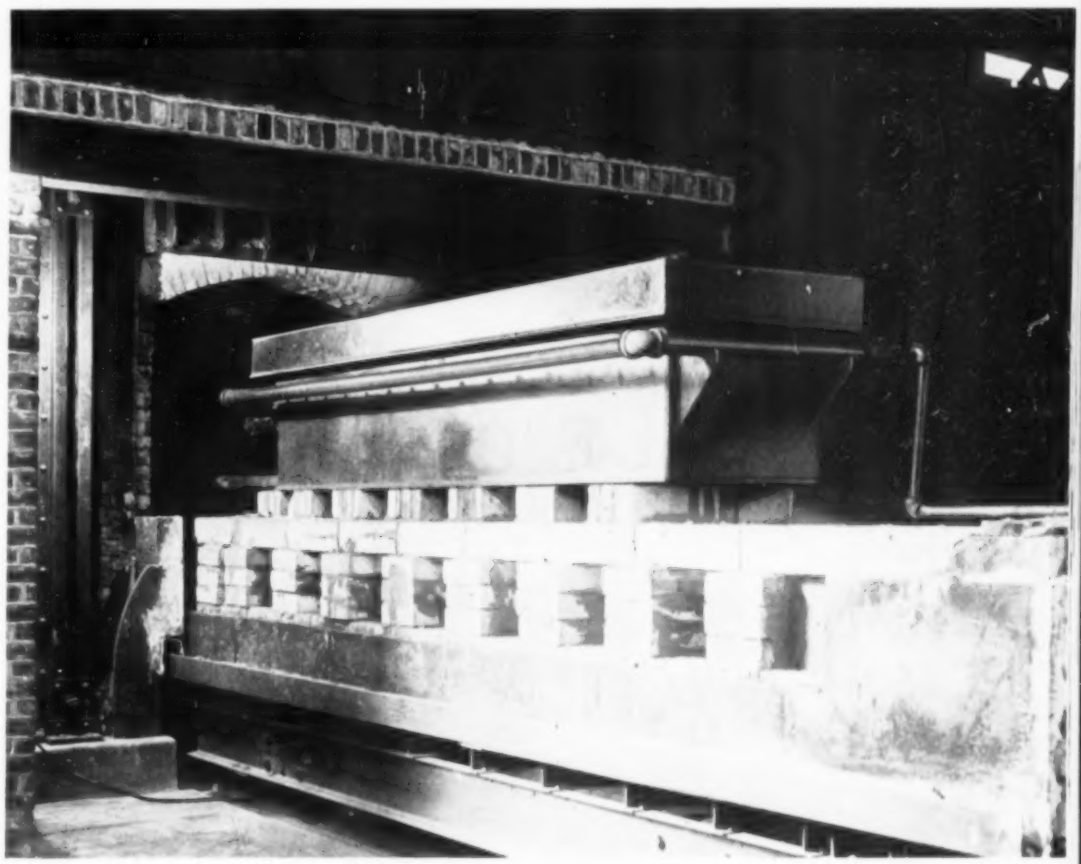
Hardness undoubtedly is its chief feature. Higher surface hardness can be obtained by nitriding than by any other known means of case hardening or heat treating. An illustration showing the comparison in gradation hardness of the nitrided case and the case hardened surface is shown in the first diagram on the opposite page. A second feature of the nitrided case is that it may be heated to 925 deg. Fahr. without loss in hardness — which, of course, is impossible with case hardened parts.

The effect of reheating on the surface hardness of nitrided and case hardened parts is clearly shown in the middle diagram. These hardness values were obtained after the part had been cooled to room temperature. A surface with such properties is valuable for forging or upsetting dies that must not "wash" or wear.

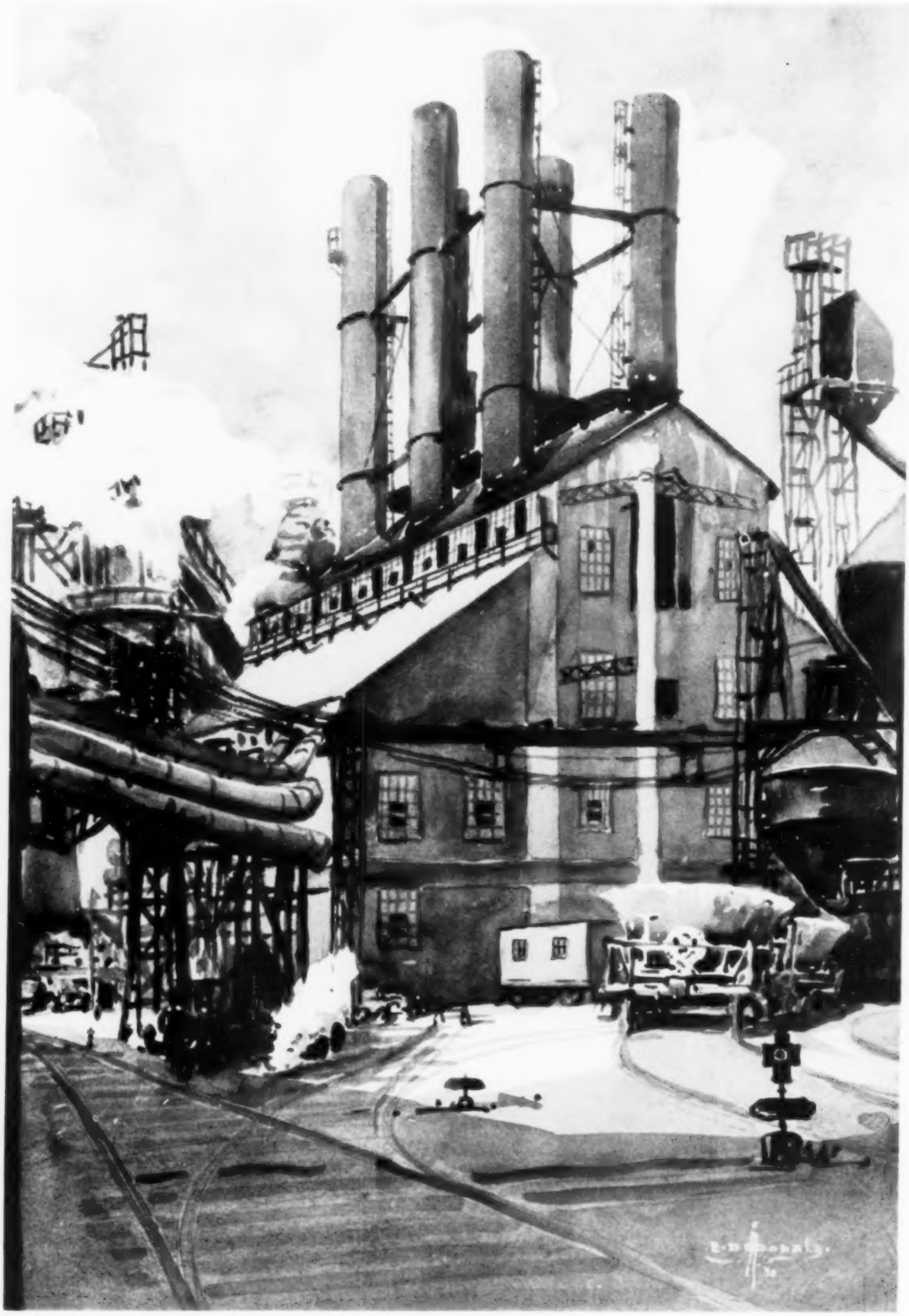
A third property is that of retaining a high hardness at elevated temperatures. Fig. 3 shows values taken from Herbert's work published in *Mechanical Engineering*, June, 1930, in which the "hot hardness" of the nitrided case is compared with that of 1.25 per cent carbon steel. It is interesting to note that the hot hardness curve for nitralloy is appreciably higher at 400 than when cold, while the high carbon steel loses its hardness rapidly after reaching 500 deg. Fahr. These "hot hardness" values show why the nitrided cylinders and valve seats which operate at slightly elevated temperatures are giving such excellent results.

A fourth highly important property is that of the ability of the nitrided case to resist corrosion of atmosphere, crude oils, alkalis, tap water, gasoline and salt spray. This feature is very desirable for machinery which otherwise would be slushed with oil.

A fifth feature is that, when properly pre-



pared, small and intricate parts as well as large heavy parts, may be hardened free from distortion. Small intricate parts used in the movietone camera may be contrasted with the locomotive cross-head guides and pistons. Large rolls 12 in. diameter by 10 ft. long have been nitrided and held to 0.001 in. straightness. Details of the process for the largest work were described by J. H. Higgins at the recent Chicago Convention, American Society for Steel Treating. The furnace illustrated above is used by him.



Reproduction of Water Color by E. D. McDonald, Done at the Central Furnace Plant of the American Steel and Wire Co., Cleveland

In the Blast Furnace Yard

Progress in Grey Iron Castings

By Hyman Bornstein

OF ALL the engineering materials, considering its wide use, cast iron is the least known. The progress made in the field of grey iron castings within recent years has not been called to the attention of the engineer and the layman with sufficient emphasis. And there has been great progress recently in the industry.

Recently, occasion was had to refer to a prominent handbook used by engineers and surprisingly enough the information given in those pages about cast iron was taken from a source published in 1893! Certainly the engineer would not be satisfied with information on steel which dated back to so remote a period. The castings produced thirty or forty years ago, despite "the good old times," would be considered quite inferior to the castings of today. We all know something of the various grades of carbon and alloy steels and the effect of heat treatment on various properties of these

materials. But how many of us know that cast irons are made with varying carbon content, that alloys are added for specific purposes, and that many castings are subjected to heat treatment? Steels have been well classified and have become known according to composition, but such a classification has not yet been accomplished for cast iron.

In the judgment of too many of us, cast iron is just "cast iron," a material low in price and short on physical properties. We forget that in many services, cast iron is the best material that can be used for the purpose, regardless of price.

There are foundries making grey iron castings where the methods employed in respect to melting, molding, pouring and cleaning are slipshod. While the product obtained is sold as cast iron, it is certainly not up to the standard of the industry. Quite frequently, the poor opinion the engineer has about grey iron castings is based on a product from such a source.

In recent years, more and more grey iron foundries have been put under technical control and the scope of such control has grown so that today a dependable product of desired physical properties can be obtained. The foundryman, the foundry engineer, and the metallurgist have collaborated to improve the quality of grey iron castings.

Carbon Control Most Important

The most important element in cast iron is carbon. The effect of the other elements is largely the effect which they have on the carbon.

In cast iron, it should be well known that the carbon exists in two forms; combined carbon (chemically combined with the iron) and graphitic or free carbon. The total and the relative amounts of these two determine to a large extent the physical properties of the casting. The more combined carbon, the harder the iron; the more free carbon or graphite, the softer the iron.

This View, At 75 Diameters, Shows the Way Coarse Graphite Flakes Subdivide the Metal and Produce a Soft, Weak, Gray Cast Iron.

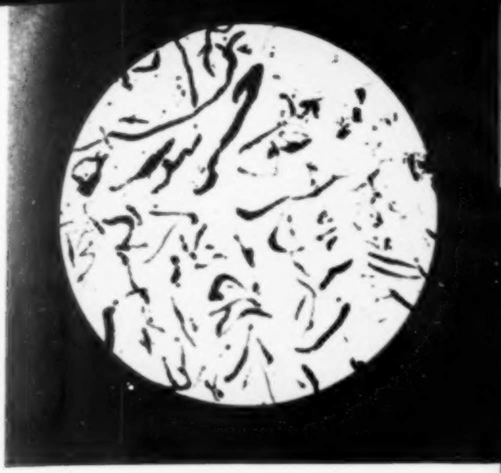
Elements such as silicon tend to throw the carbon to the free form or graphite, while other elements such as sulphur and chromium tend to increase the amount of carbon in the combined form. Hence, certain elements are known to the foundryman as softeners while others are known as hardeners.

The term "total carbon" is also frequently used in connection with cast iron. It is the sum of the free and combined carbon. As a general rule, the lower the total carbon, the higher the strength of the iron.

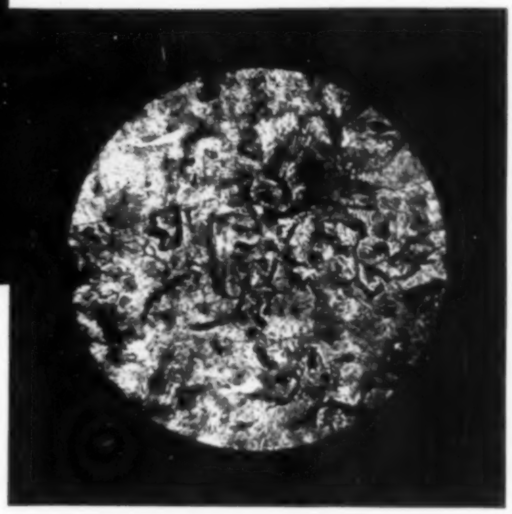
Recent developments in cast iron have been towards the production of the so-called "high-strength" cast irons. A number of practices have been used, but usually the important thing is to obtain a cast iron containing low total carbon. It has been possible to secure cast iron which will run uniformly 50,000 lb. per sq. in. tensile strength (or even better) by producing a cast iron having a total carbon content ranging from 2.75 to 3 per cent. Soft irons will run approximately 3.5 per cent carbon or higher, while irons used for automotive cylinders which are melted with about one-fifth steel in the cupola charge, will range in the neighborhood of 3.25 per cent total carbon.

But carbon is not the only influence. The strength of an iron is also dependent upon the composition in other elements, the melting practice, and the cooling rate in the mold. Feeding of the iron into the casting is also an important point, determining its soundness, and to this extent, affecting the strength of the finished part.

Frequently, test bars are used as an indication of the strength of the casting. Unless the cooling rate of the test bar is similar to the cooling rate of the casting, the strength of the iron in the test bar may be quite different than the strength of the iron in the casting. Furthermore, the casting may contain fairly high internal stresses, while the test bar would not. It should be remembered that the strength of a casting is the difference between the ultimate strength of the material and the internal stresses. Also, it is usually easier to obtain a sound test bar than it is a sound casting. Consequently, the strength of the test bar may not be a proper guide unless a definite comparison has been set up between test bar and casting.



A Nickel - Chromium Cast Iron, Unetched, At 100 Magnifications. Note how much smaller and better distributed is the free carbon.



After Etching, the Same Iron, Containing 0.65 Nickel and 0.24 Chromium, Shows Pearlitic Structure When Examined at 250 Diameters.

The design of a casting is extremely important. It may be such that it is well-nigh impossible to secure a sound casting. Consequently the designer should work with the foundryman to the end that a sound casting may be produced economically. One of the most important steps in the foundry industry has been a realization on the part of the designer that such co-operation is necessary to obtain the best results.

There have been three outstanding developments in grey iron castings in recent years:

(1) High strength cast iron,

(2) Alloy cast iron,

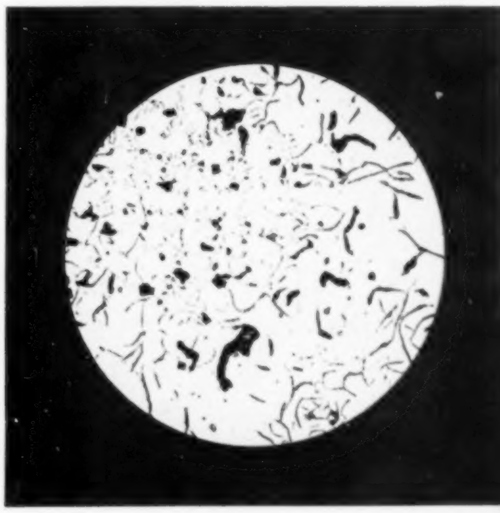
(3) Heat treatment of grey iron castings.

High strength cast iron can be secured in a number of ways. One process which is in considerable use in Europe but has not been used very much in this country is the "Perlit" process. In this process, a low silicon iron is poured into a heated mold. An iron with such a chemical composition would have a white fracture if poured into a mold under ordinary conditions, but heated molds retard the cooling so that a grey fracture is obtained, with a higher strength than ordinary cast iron.

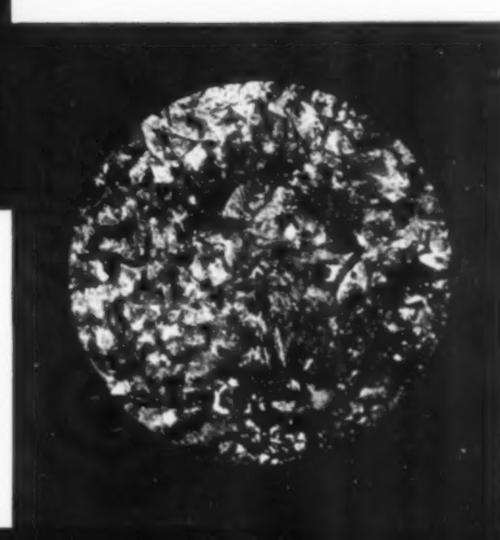
Another process for producing a high strength iron is to use a higher percentage of steel in the mix going into the cupola. Mixes consisting almost entirely of steel scrap have been melted with the result that a low total carbon content has been obtained and a resulting strong iron. Irons ranging in strength above 60,000 lb. per sq. in. have been manufactured by this method. Sometimes nickel has been added, principally to increase the machinability of the castings.

A third method of securing high strength iron is by the duplex process. In this the iron is melted in the cupola and then refined in the electric furnace. The superheat of the electric arc and a close control of the carbon content results in a strong metal.

A method which has been developed in this



Condition of Free Carbon in High Strength Iron. Tensile Strength About 50,000 lb. per sq. in. Unetched. Magnification 100 Diameters.



Same High Strength Iron, Etched With 1 per cent Nital, and Magnified 100 Diameters.

country, consists of the addition of calcium silicide to the molten iron. The resultant metal is known as "Meehanite." High physical properties have been claimed for this material.

With the development of irons ranging in tensile strength from 40,000 to 60,000 lb. per sq. in., the grey iron industry is ready to recover lost ground and to move forward. These high strength irons form an intermediate product between the ordinary cast irons and malleable and steel castings.

The use of steel scrap for producing high strength cast iron has been very popular in this country. For making automobile cylinders, as much as 20 to 25 per cent in the cupola has been the general practice. This gives a strong and dense material. Its tensile strength will probably range from 30,000 to 40,000 lb. per sq. in.

Furthermore, the addition of alloying elements such as nickel and chromium has become quite popular. Chromium is frequently added to increase the hardness of the metal while a combination of nickel and chromium will frequently increase both hardness and strength without reducing the machinability. Nickel alone is often added to increase the strength or to obtain machinability. When an increase in strength is desired, the nickel may be substituted for some of the silicon with advantage.

A continually increasing quantity of grey iron castings is being heat treated. In the automotive industry, particularly, such heat treatment is largely for the purpose of increasing the machinability of the product. Three types of heat treatment may be employed:

(1) Heating at a temperature not exceeding 1000 deg. Fahr., which will have very little effect upon the strength, hardness or machinability, but will prevent subsequent warpage of the casting by removing the internal stresses.

(2) Heating at 1000 to 1500 deg. Fahr., which will remove internal stresses and make the iron softer and more machinable.

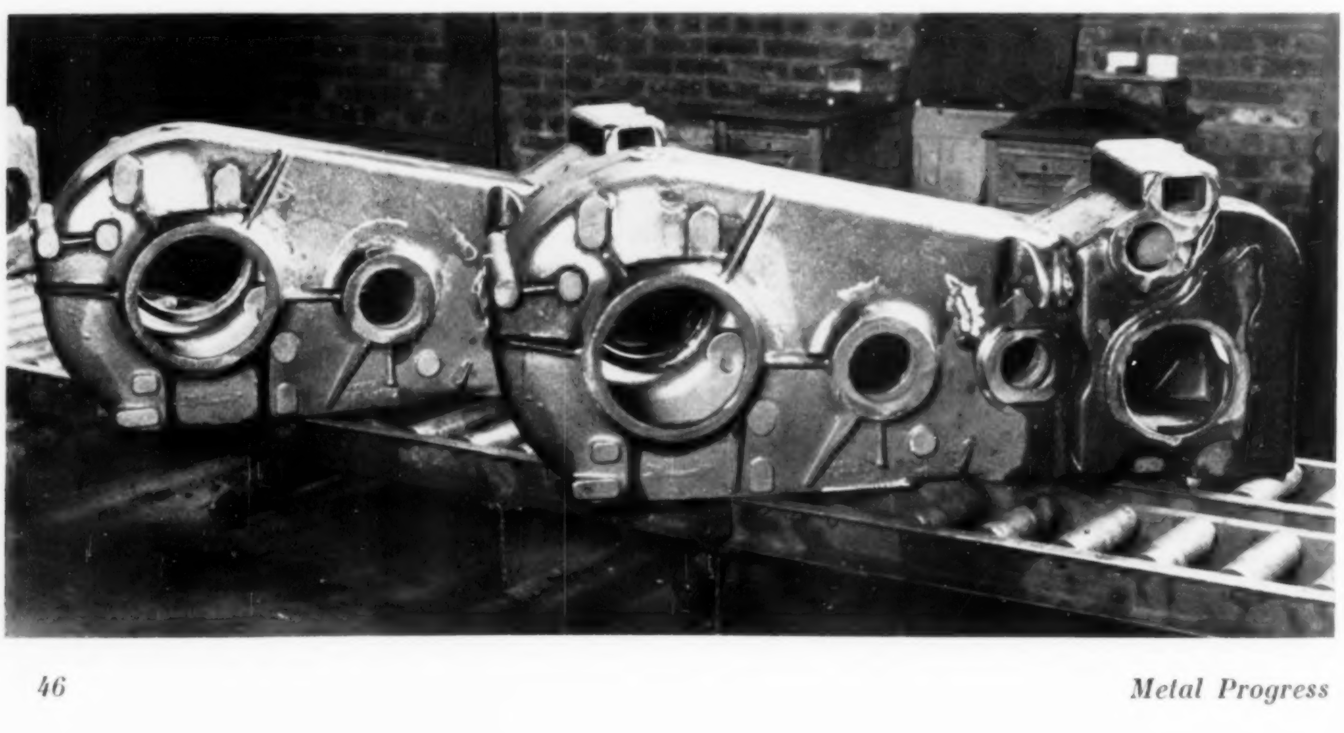
(3) Heating at 1350 to 1600 deg. Fahr., followed by a quench which will increase the hardness to a considerable extent and give grain refinement. Sometimes such a treatment is followed by a draw.

A heat treatment such as No. 1 is used largely for automobile pistons. For such parts, it is necessary to prevent warpage.

A heat treatment such as No. 2 is largely used to increase the machinability of automotive castings. It must be realized that while the machinability is increased, frequently the strength is decreased. In some cases, there is too much of a tendency to sacrifice strength for machinability.

The quantity of castings subjected to a heat treatment such as No. 3 is small. This field offers promise and it is probable that additional work will be done.

Transmission Cases For Tractor, Made of Grey Iron, Each Weighing 600 Lb. These cases are made by production methods, with molding machines and sand slinger moving down the aisle, and with molds handled by overhead cranes and set upon the floor just cleaned of sand heaps.



Heat Treatment of Low Carbon Steel

Conditions Necessary for Success

MOST text book writers seem, in general, to have ignored the possibility of increasing the useful properties of low carbon steel by heat treatment, dismissing the matter by saying that rolled steels containing less than 0.30 per cent carbon cannot appreciably be affected. Some have recorded the fact that low carbon steels may be hardened on quenching from certain temperatures, but little attempt seems to have been made to use the idea commercially, with the exception of the data recorded by one author who will be quoted later.

Bradley Stoughton says in his book, "The Metallurgy of Iron and Steel," third edition, page 405:

"Although iron free from carbon is hardened by rapid cooling from above the point Ac_2 (1650 deg. Fahr.) yet this degree of hardness is so slight as to be perceptible only by means of laboratory tests. With 0.10 per cent carbon, the hardness begins to be perceptible by crude tests, but it is only when we get to above 0.75 per cent carbon that ordinary steel acquires sufficient hardness for the process to be used commercially — for example, for springs, saws, etc."

Stoughton also gives the table shown in the opposite column. It will be shown later that the steels used in these determinations must have been of the "non-regenerating" type, and were insufficiently deoxidized or else low in manganese content. Under proper hardening conditions with properly made steels, very much greater quench hardness may be obtained.

Per cent Carbon	Brinell Hardness	
	Annealed	Hardened
0.10	97	149
0.20	115	196
0.25	143	311

A. P. Mills, in his "Materials of Construction," second edition, section 5, page 96, states:

"Water quenching at 1500 deg. Fahr. increases the strength of low carbon and medium carbon steels greatly; the ductility is reduced enormously for the low and medium carbon steels, and is practically zero for high carbon steels.

"Reheating to 1025 deg. Fahr. after such water quenching largely nullifies the gain in strength of low and medium carbon steels."

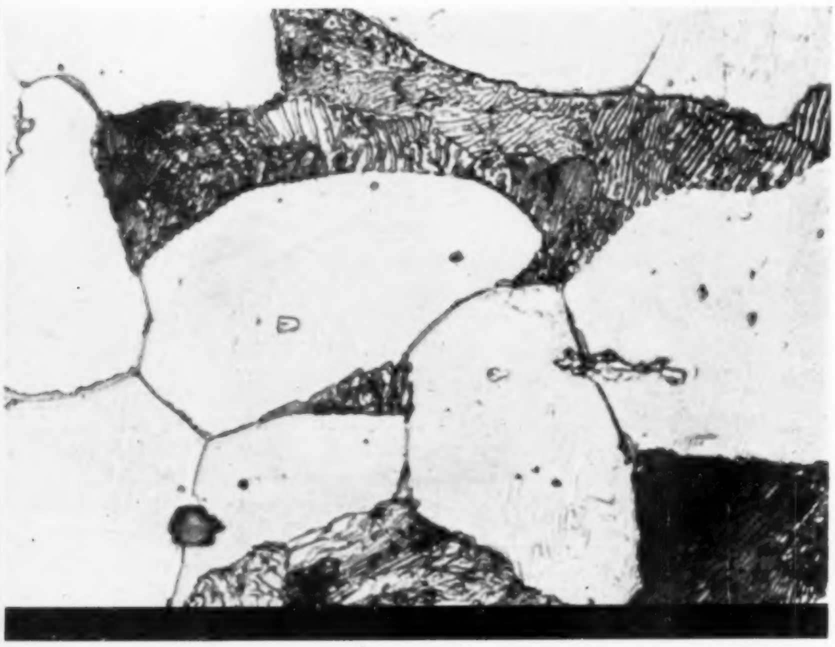
Many experiments conducted in the writer's laboratory have given results at variance with these statements.

In an article printed in *Transactions*, American Society for Steel Treating in May, 1925, R. H. Smith records tensile strengths as high as 160,000 lb. per sq. in. obtained in commercial production from 0.09 per cent carbon steel in the

By Welton J. Crook

form of rivets and bolts. Quenching conditions were distinctive — a very high velocity of the cooling medium. The present writer has obtained a tensile strength of 182,200 lb. per sq. in. in quenched plain carbon cast steel containing 0.23 per cent carbon and 0.63 manganese, using ordinary quenching methods.

D. K. Bullens seems to be one of the few writers who has recognized the possibilities which lie in the heat treatment of low carbon steels for improving their physical properties.



Microstructure of S.A.E. 1020 Steel, Capable of Regeneration. Magnification 1000 diameters. Brinell 150.

In this connection he states, in his book "Steel and Its Heat Treatment," third edition, page 188:

"The very low carbon steels find but little application to general heat treatment purposes when the cooling rate from the upper critical range is normal; that is, when the steel is simply immersed in the water or oil quenching bath without undue increase in the velocity or pressure of the cooling medium. Under these conditions the normal treatment would be a quenching from 1700 to 1525 deg. Fahr., according to the carbon content and mass-surface factors, with or without reheating, the reheating being omitted when conditions (of strain caused by quenching) will permit. Such a treatment will refine the grain and remove any strains set up by previous working; will confer added toughness; and will put the steel in the best condition for many machining operations."

He obtained the results shown in the table at the bottom of this page when pulling heat treated 3/8-in. test bars of acid steel, having 0.10 per cent carbon, 0.32 manganese and 0.02 silicon. Continuing the discussion of 0.15 to 0.20 carbon steels, Bullens states:

"Heat treatment of the lower carbons of this range confers but little additional strength except in thin sections normally quenched, or with small pieces quenched under high cooling rates.

The Question of Proper Quenching Heat

"Hardening should be carried out from a temperature exceeding the end point of the upper critical range — which is about 1570 deg. Fahr. for the 0.15 per cent carbon and about 1510 deg. Fahr. for the 0.25 per cent carbon — in order to effect the full absorption and diffusion of the excess ferrite. Some engineers recommend quenching at 1650 deg. Fahr. or even higher, but the author believes that such temperatures are not only detrimental, on account of a greater tendency to warping, oxidation, and higher cost of treatment, but also are unnecessary metallurgically.

"With hardening temperatures higher than 1550 deg. Fahr. for 0.20 per cent carbon, there is practically no increase in the physical properties worthy of mention, and, moreover, the

Condition	Ultimate Strength	Elastic Limit	Elongation in 8 in.	Reduction of Area
As rolled	51,600	35,500	34.5	65.3
Annealed	48,800	31,700	37.5	67.5
Water quenched, 1575°F.	64,720	45,500	22.8	61.1
Same, then drawn, 1300°F.	53,000	36,500	35.3	66.0

structure then begins to coarsen very rapidly.

"With carbons greater than 0.20 per cent and particularly if the section is small, or the manganese content is more than 0.6 per cent, the necessity of reheating or toughening after quenching becomes apparent."

It is quite evident that Bullens recognized the possibilities of heat treatment, but ample experimental evidence exists to show that a quench temperature of between 1600 and 1650 deg. Fahr. should be used. Such experiments show that not all low carbon steels will react to the treatment. The ability to do so is probably dependent on the presence of at least 0.5 per cent manganese and a more or less complete state of deoxidation. Crook obtained a patent, No. 1,592,181, based on these findings.

Conditions Necessary for Hardening

Examination of many quenched specimens shows that where hardening does not take place, either the ferrite did not go into complete solid solution or if it did, the solid solution (martensite) was not preserved. In the first condition, the unabsorbed ferrite is generally associated with or surrounding non-metallic inclusions. There is some reason to suspect that these primary ferrite areas, formed during solidification of the ingot, contain little or no manganese.

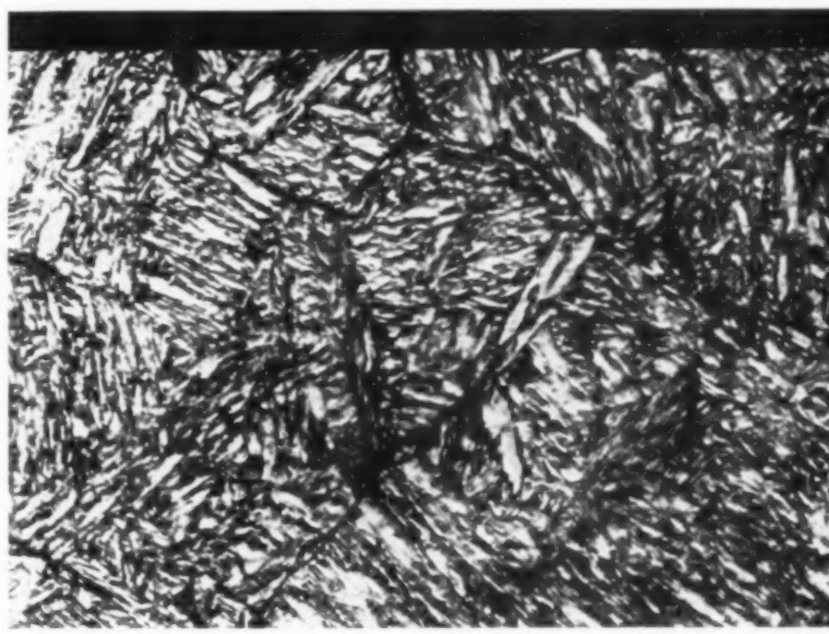
In the second case — where the quenching was unable to preserve the martensitic structure — the steel as a whole is found to contain less than 0.5 per cent manganese, and is probably more or less oxidized. Such conditions will be found after attempting to harden mild Bessemer steel.

Low carbon steels which heat treat satisfactorily must be of the completely "regenerating" type. The mechanism of ferrite absorption in such a steel proceeds as follows:

As the steel is heated, little change takes place until a temperature slightly under the transformation point is reached (about 1300 deg. Fahr.). If such a specimen is quenched in cold water and examined microscopically, it will be found that the pearlite laminae are not as distinct as they were in the original steel. The steel has slightly hardened, and the grain size decreased about five per cent. From a theoretical point of view, no such changes *should* occur below the Ac_1 point; however, the conditions described have been observed by the present author many times.

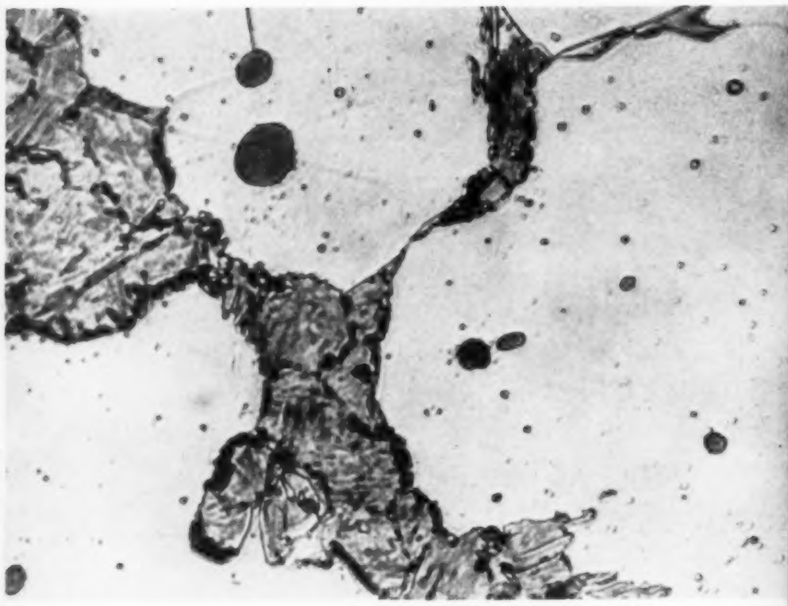
Proceed with a series of water quenches from increasing temperatures, with subsequent microscopic study. In a "regenerating" steel quenched from just over the Ar_1 point (say 1350 deg. Fahr.), the original ferrite areas remain substantially unchanged. The solid solution, austenite, will not be preserved by quenching, but in its place martensite will be retained in the original pearlite areas. These martensite areas are very hard, and are similar to the martensite of quenched steel having 0.90 per cent carbon. Measuring the hardness of the apparently un-

Steel Shown Opposite, Completely Regenerated After Water Quenching From 1600 deg. Fahr. Magnification 1000 diameters. Brinell 600.

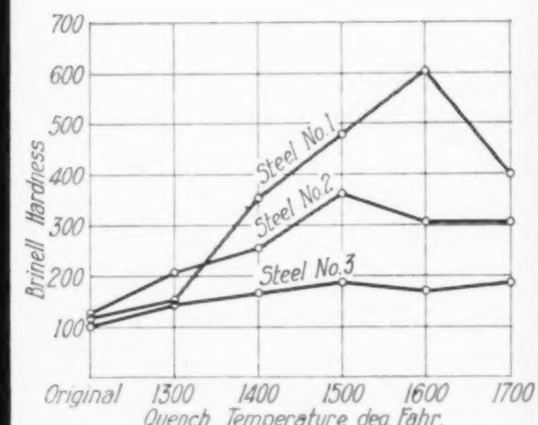


changed ferrite grains by means of a microcharacter, shows that they also have materially increased in hardness in the ratio of about 247 micro hardness for the as-rolled to 300 micro hardness for steel quenched from a temperature of 1350 deg. Fahr.

As the quench temperature is raised higher and higher above the Ac_1 point, the martensitic areas become increasingly larger, gradually absorbing the ferrite. When the Ac_3 point is reached, the last of the ferrite has disappeared and the quenched specimen consists entirely of



Bessemer Screw Stock at 1000 Diameters. After water quenching from 1600 deg. Fahr. the original pearlite areas in this non regenerating steel are occupied by martensite, but the ferrite is not absorbed. Brinell 170.



Steels 1 and 2 Have About Same Analysis (0.23 Carbon, 0.59 Manganese) but No. 2 Cannot Be Improved Much By Heat Treatment; Steel 3 is Low Carbon Bessemer Screw Stock.

low carbon martensite. This martensite, in well deoxidized steels, exhibits a surprising degree of hardness, often exceeding 600 Brinell.

The formation of low carbon martensite with the attendant absorption of free ferrite may readily be followed by measuring the hardness of the specimens after quenching. If a low carbon steel reaches a Brinell hardness of over 500 when quenched from just above its Ac_3 point, it is said to "regenerate" and to be suitable for heat treating.

The curves on this page were obtained from three steels having the analyses noted in the accompanying tabulation. It is obvious that little can be learned from the chemical analysis of a steel in regard to its ability to react to heat treatment.

Steel No. 2 contained definite and persistent ferrite ghost lines which could not be absorbed on heating. Its failure to regenerate was probably caused by poor deoxidation in the steel making furnace. Steel No. 3 was a Bessemer screw stock. Bessemer steel seldom reacts to heat treatment on account of excessive oxidation.

Steel No. 1 is a good regenerating steel, and its microstructures before and after quenching are shown on pages *48* and *49*.

Many experiments have shown that low carbon steels containing less than 0.5 per cent manganese will rarely harden. A possibility exists that no critical amount, such as 0.5 per cent of manganese, is necessary for regeneration, but that steels containing less than this amount are generally poorly deoxidized. This point is difficult of proof.

It has been observed that electric steels, which as a class are better deoxidized than those made by the open-hearth process, will regenerate with a somewhat lower manganese content. In this connection it is found that if a piece of Armco iron is carburized so as to produce a wholly pearlitic case, no amount of heating will cause the martensite retained on quenching to migrate or absorb ferrite. This represents a steel without manganese and highly oxidized. On the other hand, low carbon open-hearth steel, which has been thoroughly killed with silicon in the furnace, has been found to be uniformly suitable for heat treatment.

	No. 1	No. 2	No. 3
Carbon	0.23	0.24	0.06
Manganese	0.60	0.58	0.49
Phosphorus	0.04	0.03	0.04
Sulphur	0.07	0.05	0.12

Test Results	As Rolled	Heat Treated
Ultimate strength	62,200	82,680
Yield point	40,200	65,500
Elongation in 8 in.	32	20.5
Reduction of area	60	60
Bend test	Flat cold	Flat cold

Although low carbon steel may be treated so as to assume a very high degree of hardness, such steel is not suitable for edged tools. A chisel made of 0.20 carbon steel and hardened to 600 Brinell did not dull, but turned its edge. The chisel bent more than 30 deg. before breaking. This property of hardness, coupled with ductility, is unique but apparently of little practical value.

Fully hardened low carbon steels have but little practical application unless the structure and properties are modified by reheating or drawing. The steel must first assume a completely martensitic structure on quenching from proper temperature. Over-heating results in a very rapid grain growth with corresponding loss of hardness. When the properly quenched steel is again heated to various temperatures, a large range of physical properties can be obtained so that the material may be applied particularly for structural purposes where higher elastic limits, together with a high degree of ductility and malleability, are required. If an elongation of 20 per cent in 8-in. gage is the minimum requirement, it is believed that heat treated low carbon steel will give higher properties than any of the ordinary heat treated alloy steels.

From a large mass of data which has been obtained by the writer, one example will suffice to illustrate the properties which may be obtained. Optimum results will not be given, but simply those which may be expected from ordinary well made steel.

The analysis of the steel showed carbon 0.14 per cent and manganese 0.58. It was hot rolled basic open-hearth, and was treated and tested in the form of 2 by ½-in. flats about 30 in. long. The treatment consisted in water quenching from 1600 and drawing at 1000 deg. Fahr. for 30 min. The properties obtained are listed in the table at the left.

Structural steel specifications usually call for a minimum elongation of 20 per cent in 8 in. Yield point rarely exceeds 40,000 lb. per sq. in. but by special rolling methods, a yield point as high as 45,000 lb. per sq. in. may be obtained. By proper heat treatment these figures may be greatly exceeded.

Last year, Lieut. P. F. Lee and Lieut. H. A. Schade, United States Navy, were detailed under the writer's direction to make a study of the possibilities of heat treated low carbon steel for ship construction. These officers made a long and careful study, using many specimens obtained from Navy Yard stock and from a local steel producing company. The results of a part of their tests were reported in an article which was published in *The Iron Age* for Feb. 13, 1930.

They reached the following conclusions as a result of their experiments:

(a) Steels containing less than 0.20 per cent carbon, at least 0.60 per cent manganese, and completely deoxidized, will have their tensile strengths definitely improved after they have been given suitable heat treatments.

(b) The increase in tensile strength is accompanied by a decrease in ductility. The percentage increase in tensile strength, however, is greater than the percentage decrease in ductility, as measured by per cent elongation.

(c) The regeneration test is a rapid and accurate method of determining the suitability of a steel for the proposed heat treatment. A regeneration hardness of at least 350 Brinell is considered necessary before any great improvement in the steel can be expected from the heat treatment.

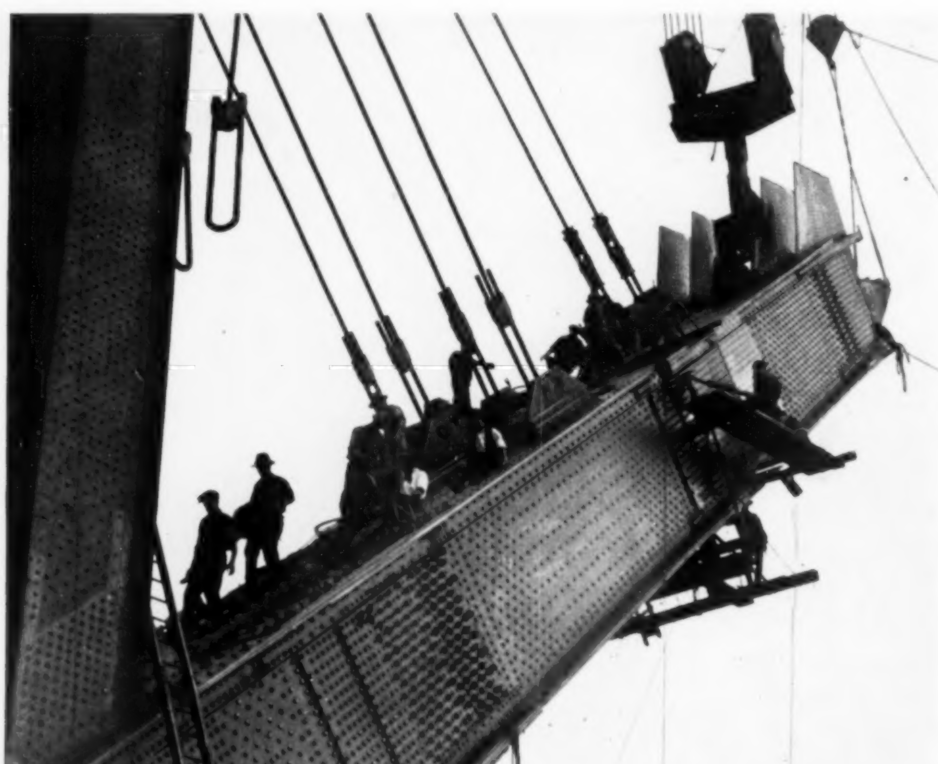
(d) Results can be duplicated with reasonable exactness.

(e) The elastic ratio of the steel is increased by the proposed heat improvement. While high ultimate strength is of great importance, a high elastic limit is of nearly equal importance. Stresses beyond the elastic limit will produce permanent deformation or partial failure of a structure, a result which in certain cases might be equally disastrous as complete failure.

(f) Welding on this steel after heat treatment must be done with great caution. If the welding can be performed before heat treatment, no injury to the steel will result therefrom.

(g) The heat treatment recommended depends primarily on the physical properties desired in the finished product. For most uses where a steel of high strength coupled with good ductility is desired, a draw temperature of 1100 deg. Fahr. is recommended. This should produce a steel having a tensile strength of about 90,000 lb. per sq. in., an elastic limit of about 70,000 lb. per sq. in.; and an elongation of about 30 per cent in 2 in. Such a steel compares very favorably with various low alloy steels. In those structures where ductility is of lesser importance, a lower draw temperature should be used. This would result in an increase in the tensile strength and elastic limit. Draw temperatures lower than 900 deg. Fahr. are not recommended due to the great brittleness of the steel when so treated. Draw temperatures higher than 1300 deg. Fahr. add so little to the tensile strength of the original material that their use is not considered justified.

The regeneration test mentioned by Lee and Schade is carried out as follows for a 0.15 to 0.20-per cent carbon steel: A test specimen, not exceeding a one-inch square, and generally about three inches long, is heated at 1600 deg. Fahr. for about 30 min. and then quenched in cold water. After removing the scale and producing a smooth surface on a grinder, the specimen is tested for hardness by either a Brinell or Rockwell machine. The writer believes that a minimum Brinell hardness of 500 or a Rockwell of C 54 should be obtained from a steel which will give the highest physical properties after heat treatment. It is possible, however, that for ordinary structural purposes a steel giving 350 Brinell will suffice when properly treated.



Much Heat Treated Structural Steel Is Used In the Arch Bridge Across Sidney Harbor, in Australia.

Aluminum Street Cars . . save one fifth the weight

By A. M. Robinson

ONLY A FEW YEARS less than a century after the reduction of alumina to metal in the scientific laboratory, and approximately a half century after the first introduction of aluminum to the public, we find aluminum alloys employed to a considerable extent in the art of electric car building. Development of this important metal has all occurred within a comparatively few years; in fact, it was only 123 years ago that the first attempts were made to separate alumina, the oxide, from its sources, whereas today we find a variety of aluminum alloys employed in constructing electric cars for the most exacting service of furnishing mass transportation to the American public.

Because of its light weight aluminum has long been regarded as a possibility, and one most desirable, for structural purposes, particularly in transportation vehicles. The problem, however, involves more than the production of alloys capable of standing up in service, since the cost of the metal is a limitation which must not be forgotten.

Prior to 1926 the use of aluminum by car builders was confined to panels on car sides and such other members as are subject only to nominal stresses. Wherever strength to withstand impact was an essential, producers of the metal had yet to furnish suitable materials. The American Car & Foundry Co., a firm closely identified with the manufacture of steam railroad equipment, used aluminum for interior finish, moldings, window panels, and various fittings as early as 1904 in a lot of 300 motor cars and trailers built for the New York subway. I believe this was the first application of this light weight metal to public transportation equipment.

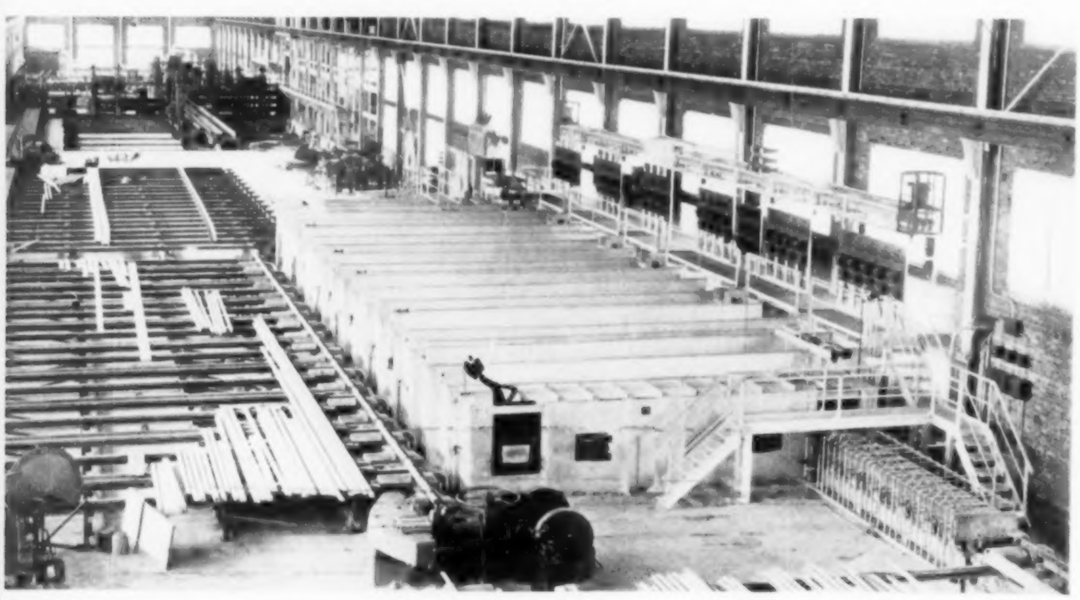
Then in the following year J. G. Brill Co. used aluminum for the headlining or ceilings of

15 full-convertible cars for the Manila Electric Railroad & Light Co., Philippine Islands, and also for air pipes, hand rails and fittings in 200 semi-convertible cars for the Chicago City Railroad Co.

Continued use of aluminum by car builders was, of course, greatly restricted on account of its comparatively high cost, and it is significant that for a period of 18 years following these first applications, only the conventional materials were used for these various purposes. Between 1923 and 1926 a number of builders again used aluminum in a more or less limited way for roofs, inside finish, conduit fittings, junction boxes and other small parts.

In the meantime the Aluminum Co. of America was putting forth strenuous efforts to develop high strength light alloys and methods of manufacturing them in sizes and shapes large enough for structural fabricators. As a result of this effort, the first all-aluminum street car made in America was exhibited at the 1926 convention of the American Electric Railway Association in Cleveland. It was built according to the standard design of the Cleveland Railway Co., and mounted on aluminum trucks designed and built by J. G. Brill Co. While no attempt was made to adapt the design of this car for the use of aluminum (the original drawings for the company's standard steel car being used) the remarkably low weight of 30,300 lb. was attained, which was 12,900 lb. less than a twin car built of steel.

Rolling Mill for Aluminum Shapes



Following the Cleveland sample car, a number of other sample cars were built for Pittsburgh, Springfield, Mass., Joliet, Ill., and St. Louis. The one for Pittsburgh was all aluminum except wheels, axles, springs and electrical parts.

There are, of course, some parts of electric cars such as wheels, motors, floors and glass for which aluminum cannot be used. But it is figured that wherever aluminum is used and the part designed to provide strength equal to that of steel, the material weighs only about half of that replaced.

During the past few years the electric railways have been contending with other types of public transportation, such as private automobiles, taxi cabs and motor buses. This sharp competition has not only demanded economical operation on the part of the entire traction system but also increased efficiency in the individual car. By the substitution of light weight alloys of aluminum for heavier metals, principally steel, the following advantages become apparent:

(1) *Lower power consumption.* This is probably the most outstanding economy, and over a period of years offers a worth-while saving. A prominent railway engineer tells us that he can spend $1.25 for capital investment for every pound he can save in the weight of his rolling stock.

(2) *Quicker acceleration,* braking and free running speed. The lighter load placed upon the motive equipment results in quicker service and faster schedules for the public.

(3) *Reduction in brake shoe wear.* Naturally the lighter the equipment the less effort is required to make stops, so that it is logical that brake shoes should have longer life.

(4) Satisfactory performance of *smaller motors* and other parts.

(5) *Better all around performance.*

(6) *Decreased wear* on tracks.

(7) *Reduction of noise*

In Lynchburg, Va., Where Hill-Climbing Ability Is Needed, Cars with Aluminum Superstructures Are in Operation.

with lighter weight, particularly in the parts unsprung. The noise at crossings is considerably less.

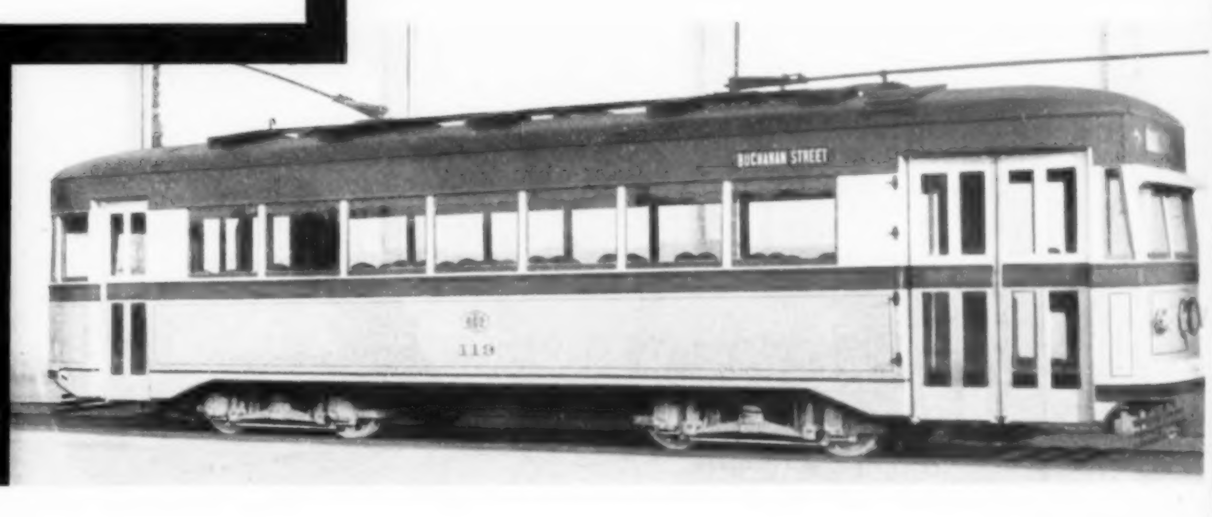
(8) Last but not least, with less dead weight in the equipment to move, the *pay load should be correspondingly increased.*

Another important consideration is the fact that the proper aluminum alloys are non-corrosive and, therefore, capable of withstanding severe atmospheric and service conditions to better advantage. Consequently, this means lower maintenance. It has been found that in painted aluminum bodies the paint adheres longer, does not peel as on other surfaces, and that a saving of from $75 to $100 per car per year should be expected from this alone.

Attention is also directed to the fact that aluminum scrap resulting from damaged parts can be sold at from 40 to 60 per cent of its first cost, so that although the original cost is higher there is a reduction in replacement parts due to the high scrap value of the metal.

Parts Frequently Made of Aluminum

It has been found practical to use aluminum alloys for many parts on both car bodies and trucks, and, of course, the saving in weight of the finished car depends entirely upon the extent to



which aluminum alloys are substituted for steel.

Underframe: Side sills, center sills, crossings, cover plates, platform knees, buffer parts, bolsters, floor beams, trap doors, anti-climbers and body center plates.

Superstructure: Side posts, door posts, vestibule posts, door headers, carlines, roof sheets, letterboards, side sheets, doors, headlining, advertising racks, bulkheads, inside finish, window sills, window post capping, stanchions, conduit, junction boxes, brake levers and door operating mechanism.

Accessory Parts: Air brake equipment, trolley poles, seat pedestals and frames.

Trucks: Side frames, transoms, bolsters, brake levers, journal boxes and center plates.

Several grades of aluminum alloy are available for use in the above parts of electric railway equipment.

For underframe and the framing members of the superstructure, requiring strength, both 17-ST and 25-ST are available. These sections have a tensile strength of 55,000 to 63,000 lb. per sq. in., a yield point from 30,000 to 40,000 lb. per sq. in., and elongation in 2 in. from 25 to 18 per cent.

For interior finish, seat frames and trolley poles, the 51-ST grade is recommended. This wrought alloy has a tensile strength of 45,000 to 50,000 lb. per sq. in., a yield point from 30,000 to 40,000 lb. per sq. in., and elongation ranging from 18 to 10 per cent.

For such parts as do not require the greater strength of the other alloys the 3-S grade is offered in the half-hard condition, having a tensile strength of 20,000 to 25,000 lb. per sq. in., a yield point from 15,000 to 20,000 lb. per sq. in., and elongation of approximately 20 per cent in 2 in.

For castings requiring both strength and ductility, such as trolley bases, harps, fender parts and draw bar anchorages, the 195 alloy is recommended. This alloy has a tensile strength varying with the heat treatment from 28,000 to 50,000 lb. per sq. in., a yield point between 13,000 and 29,000 lb. per sq. in., and elongation in 2 in. inversely as the strength, from 12 per cent to 2 per cent.

Up to the present time the cars which might be called all-aluminum have been limited to sample units. The present trend is to use only a part of the light alloys. This can be attributed entirely to the desire on the part of the operating companies to balance the initial cost of their equipment against the saving in weight effected by the use of aluminum alloys. In the 20 double-end city cars shown on page 55 seating 41 passengers and measuring 39 ft. 10 in. over the vestibules, built in 1929 for operation in Lynchburg, Va., the entire superstructure of the body was aluminum, while the underframe was made of steel. The complete car, equipped with four 35-hp. motors, weighed 34,720 lb., a saving of 1,700 lb. per car.

A Half-Ton Easily Saved

Then in other equipment, like the 32 cars built for Wilmington, Del., (one of which is shown on the last page of this article) aluminum was used only for sheathing, including sides, letter boards, dashers, inside finish and on the seats. These cars measure 41 ft. 1½ in. over the vestibules, seat 44 passengers and weigh 36,580 lb. A saving of 900 lb. per car was made by the use of light alloy instead of steel.

In other cases where aluminum is only used for outside sheathing and letterboard in a car 45 ft. long, a saving of 700 lb. per car is accomplished.

In order to give some idea of the possibilities in weight reduction which might be accomplished by the substitution of aluminum for steel in both car body and trucks, a set of com-

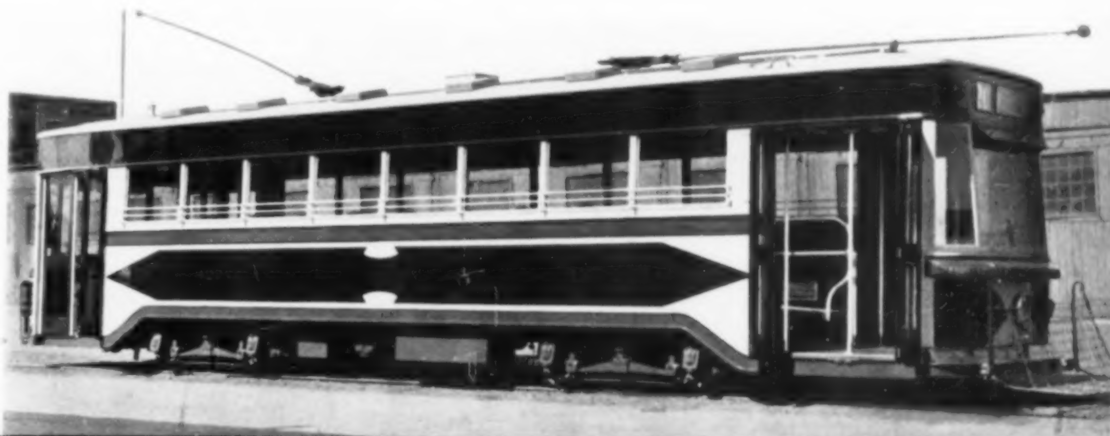
Method of Construction	50 Passenger Car for City Service			39 Passenger High Speed Car		
	Total Weight	Weight per Passenger	Percentage of Saving	Total Weight	Weight per Passenger	Percentage of Saving
Steel body and steel trucks	34,645 lb.	693 lb.		37,570 lb.	962 lb.	
Aluminum body and steel trucks	28,875 lb.	577 lb	16.7	32,055 lb.	821 lb.	14.7
Aluminum body and aluminum trucks	26,875 lb.	537 lb.	22.4	30,055 lb.	770 lb.	20.0

parative figures is given in the tabulation on the bottom of the preceding page. The double-end eight-wheel city car mentioned in the first columns of the table would measure 43 ft. 3 in. over vestibules, seat 50 passengers and would be equipped with four 35-hp. motors. The high-speed car described in the right hand section of the table is a single-end car measuring 43 ft. long and is equipped with four 50-hp. motors.

It may be stated in conclusion that the manner in which aluminum alloys will continue to be used in car construction rests entirely with the purchasing companies. Economies due to light weight, and improvement in service due to resultant increased efficiency, may justify the higher initial cost. Knowing the facts, as they are developed by a record of running expenses and maintenance costs, not only of rolling stock but of track, the operating companies can determine to what extent they desire to replace steel with aluminum alloy.

That this movement is actually under way may be inferred from the fact that the Youngstown Municipal Railway of Youngstown, Ohio, recently purchased 13 double-end double-truck cars, 38 ft. 10 in. long over vestibules, each seating 45 passengers. These cars are furnished with modern deep spring leather upholstered seats and propelled by four 35-hp motors, yet they weigh only 28,800 lb. each. In these cars various members of the body and vestibule frame were of aluminum, as were the hand poles, stanchions and a number of other miscellaneous parts.

Thirty-Two Cars of This Type Were Made Recently By J. G. Brill Co. for Wilmington, Del. Strong aluminum alloys were used for sheathing, side plates, letterboards, dashers and inside finish.



Principles of Cold Upsetting

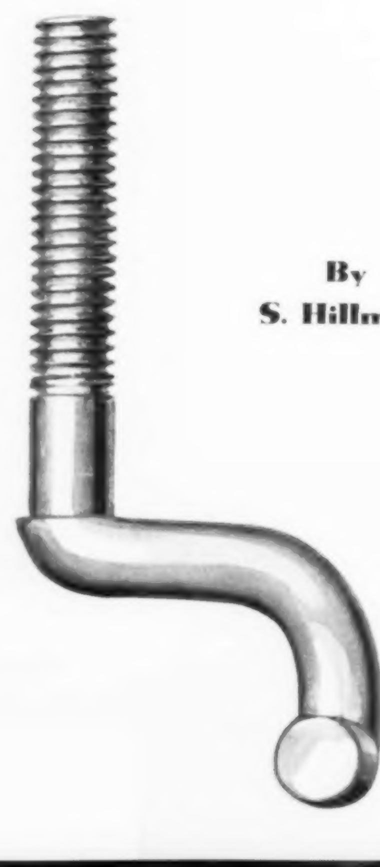
and the Limitations

COLD HEADING is the common term for cold upsetting and, in a limited field, it duplicates the results of hot upsetting without any application of heat.

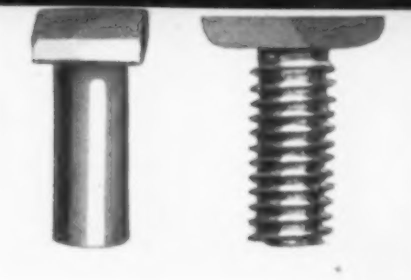
The common materials used in this process are generally plain or alloy steels of low or medium carbon content (that is to say, steels containing 0.45 per cent carbon or less), copper, many of the copper alloys including the commercial copper-nickel alloys, and aluminum and its modern alloys. Even high carbon or alloy tool steel may be handled if the work is done with care. In short, any metal or alloy now on the market in rolled or drawn condition may be cold upset to a degree varying directly as its ductility and to the extent that the strains set up by cold work are within the ultimate compressive strength of the material.

As a process of manufacturing, cold upsetting is typical of the trend of modern progress in that it utilizes the raw material to the maximum extent, and reduces to a minimum the amount of scrap produced as a necessary by-product. Starting with wire of suitable size, and with tools properly used, it is practicable to hold important dimensions within very close limits thus eliminating subsequent machining operations.

The size (that is, the diameter) of the raw material used and the amount of metal displaced or moved are factors on which definite limits are now placed. The former is limited by the size and cost of machinery heavy enough to work stock of large diameter. The latter factor is limited, as intimated above, by the ductility of the metal and also by the ability of the machines to control and direct the movement of it. Undoubtedly heading machines could be built powerful enough to cold upset stock considerably larger in diameter than is upset today, but competitive products from other lines, such as the automatic screw machine and drop hammer, set a cost limit that cannot be ignored.

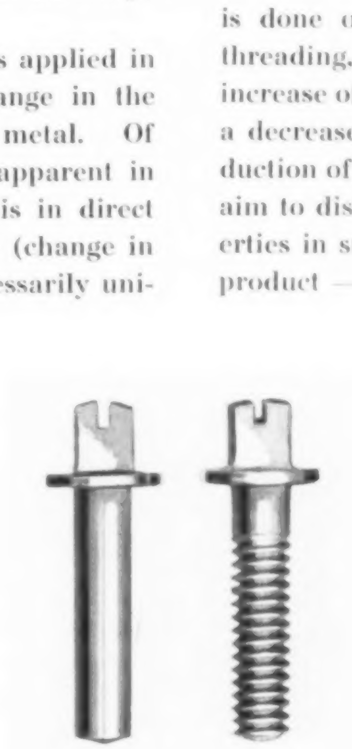


By
S. Hillman



The amount of metal that can be moved, and at the same time controlled in its movement, has a certain relationship to the diameter of the wire or rod being used. It varies from the smallest amount up to a length equal to eight or even ten times the diameter. The further the metal is to be moved the harder it is to control, so instead of trying to do it all at a single blow, the most difficult work is done in machines striking two, three, or four blows, each blow doing a definite amount of upsetting and guiding so that the final blow completes the shape desired.

It is obvious that since no heat is applied in the forming, there will be no change in the microstructure of the unmoved metal. Of course, more or less distortion is apparent in the upset section. The distortion is in direct proportion to the amount of strain (change in shape of the metal) and is not necessarily uniform throughout the upset. Strain distribution and, consequently, the granular deformation are dependent on several variables of which the most influential are: shape of upset, design of tools, use of the tools, ductility of the metal and grain size of the raw material. These are all subject to accurate control and that control must be exercised constantly in order to produce a cold-headed product of quality.



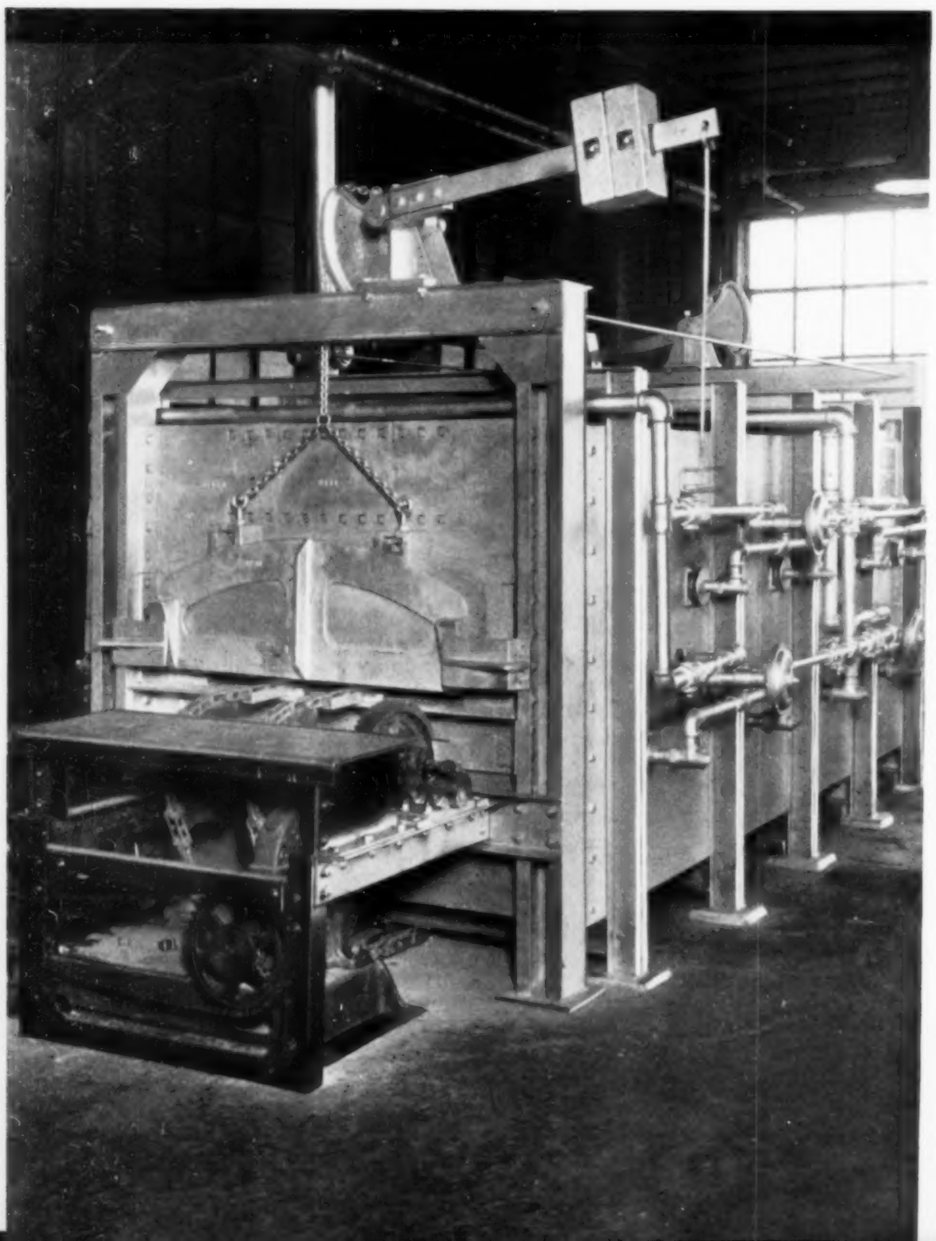
Design of the upsetting die and punches and their use are very important factors toward success, and are controlled by the knowledge and experience of the manufacturer. Experience has also taught him that the best raw material (that is, the wire) assures him the most uniform finished product with the least number of rejections and the lowest die cost. Consequently, the incoming wire is closely inspected for surface defects as well as internal structure; it is checked chemically and physically. Traces of pipe coming through from the ingot, and internal defects caused by improper wire drawing practice are sufficient cause for rejection.

Physical properties of the metal which has been upset are changed from those of the original wire only by the cold work done during the cold heading. Where no work is performed, no change takes place, but where work is done on the part (such as upsetting, roll threading, or extruding) there is a proportional increase of tensile strength and elastic limit with a decrease in percentage of elongation and reduction of area. Obviously it is the cold header's aim to distribute and place the increased properties in such a way as to improve the finished product — or at the worst to make their effect upon the product of no consequence. His ability to do this on a production basis is the difference between success and failure, although he may resort to heat treating to relieve the internal strains entirely.

Besides the removal of strains from cold work, heat treating is also used to develop the maximum physical properties of the steel, duralumin, or such other alloy which may be used and which responds to heat treatment. With modern furnaces and pyrometric control any physical specifications that may be fulfilled by the raw material can be met accurately on a production basis. Care must be exercised constantly to keep the scale and decarburization at a minimum. Heat treating is the last operation that a part receives before packing for shipment and when properly handled will give a lustrous finish.

The accompanying illustrations, either at natural size or slightly enlarged, show a few odd shapes in the smaller sizes which are cold upset. These show that the position of the upset is not limited to the ends of the piece, but may come any place between them. The shapes are shown in duplicate—illustrating the raw header blank and the trimmed and threaded product.

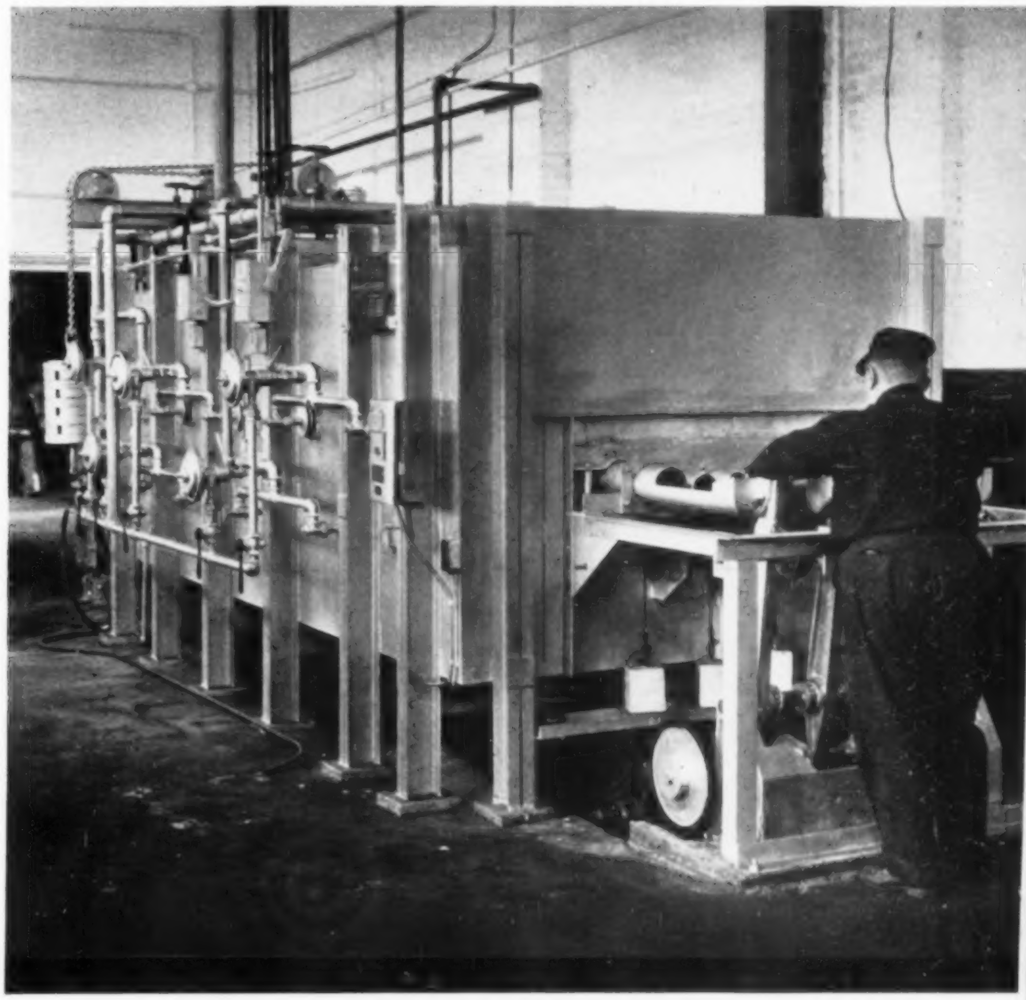
Influence of Furnace Atmospheres on Correct Heat Treatment



A GREAT DEAL of applied research has been completed which has had as its prime object the control of the physical properties of specific alloys. Chemical analysis, together with the use of the microscope, has been used by the metallurgist to check his heat treating operations, with the result that he is able to predict the usefulness of his product under unusual conditions of service.

Indeed, the progress which the metallurgist has made during the past several years in the development of special alloys for specific purposes has been stupendous. It is safe to assume that he has available all necessary data and processing methods which he must use to secure predetermined results, but his available information as to *how* he can produce these results with the furnace or furnaces at his command is incomplete.

To understand fully the changes which can and do take place in steel in the various heat treating operations necessitates a knowledge of physical, colloidal and general chemistry. Intricate as are some of the problems presented to the man who would transform a purely theoretical or laboratory experiment into the production of uniform metal parts in quantity, it does not follow that a solu-



By
E. W. Esslinger

tion cannot be found. In fact, most of the troubles in securing uniformly heat treated articles have come from the circumstance that few furnace designers or users realize that temperature control is not the only variable which influences profoundly the final results.

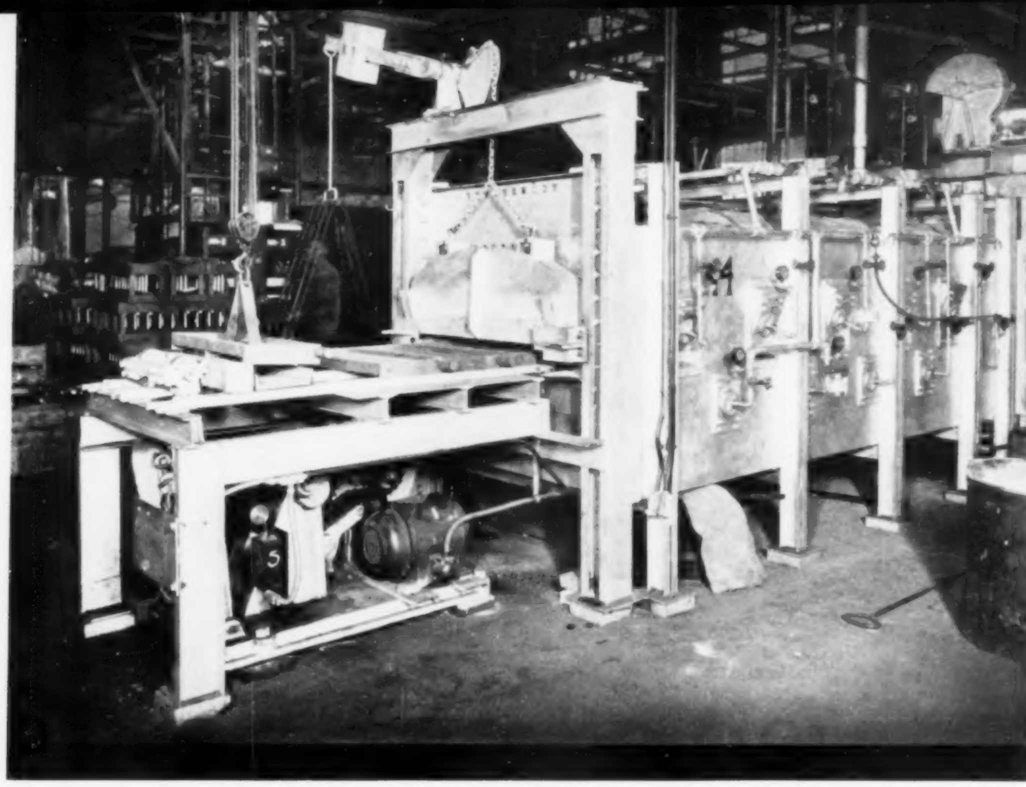
Of course, the *need* for controlled heat is essentially the same, regardless of the major operations practiced. On the other hand, *methods* of heat application and control vary with the specific nature of the process and must therefore be analyzed before any definite recommendation can be made.

The prime requisite for all heat treating operations is a properly constructed furnace. The size and design of this furnace depend upon the pieces to be treated and the temperatures required. A properly constructed furnace is one which easily attains the necessary temperature and maintains that heat uniformly in all parts, with an atmosphere which does not deteriorate the furnace and yet has the desired effect upon the pieces treated. Sometimes the desired effect is to transfer carbon into the surface of the metal. More often the atmosphere wished for is neutral to the metal in all respects.

No source of heat — that is to say, *pure heat* disassociated from the products of combustion — has any virtue over another source. Essentially, the matter to decide is: "Which source of heat is the most convenient and economical?" Gas, oil and electricity are the sources now favored, because each may be easily manipulated to produce desirable temperatures and furnace atmospheres. Consequently, choice of the fuel in most instances depends solely upon the ultimate cost of unit production.

In a good fuel fired furnace, proper atmosphere and regulated temperatures are secured by a rigid control of combustion of a common fuel. The most common fuels used in metallurgical furnaces are coal, coke, oil and gas. The main constituents of these fuels are essentially carbon and hydrogen. To generate heat by a flame it is necessary to convert the solid and liquid fuels into combustible gases. From this viewpoint, the problems of combustion simplify themselves into the problems connected with the burning of gas.

Gaseous fuels require an accurate control of



the quantity of air to be supplied for complete combustion and the control of the air is also a function of the chemical and physical characteristics of the combustible gaseous fuels. Because of the complex changes which take place in gasifying solid fuels, and because of the variable composition of the combustible gases produced, solid fuels cannot be used in furnaces which must be accurately controlled in respect to both temperatures and their atmospheres.

Liquid fuels must be gasified or atomized and mixed with air before combustion takes place. Combustion of liquid fuels may be controlled sufficiently well for many of the everyday heat treating operations, and while fuel oil furnishes a dependable source of heat, it does not lend itself easily to the accurate control of furnace atmospheres.

It follows, then, that natural and artificial gas, due to the constancy of their composition, are for the most part the only fuels that permit accurate regulation, both as to temperature and atmosphere.

The products of combustion of all types of fuel are essentially carbon dioxide, carbon monoxide, free oxygen, water vapor and nitrogen. In certain instances unburned gases are also a part of the flue gas. The percentage of each constituent in the flue gas may vary greatly, depending upon the conditions existing in the fire box, and the effects of these constituents in the flue gases upon the surface of steel being heated vary greatly and are more pronounced the higher the temperature existing in the furnace.

Some of these effects, which are not generally understood, may be stated briefly.

In furnaces at temperatures between 1600 and 1800 deg. Fahr., free oxygen causes less scale than carbon dioxide. A mixture of carbon dioxide and carbon monoxide produces the greatest amount of scale. As a decarburizing agent free oxygen is less active than carbon dioxide. Scaling can occur when charcoal is present with the metal, for carbon dioxide at elevated temperatures in contact with carbon produces carbon monoxide, which, with carbon dioxide, produces a pronounced scaling of the metal surfaces, as mentioned above. Water vapor, which is always present in the flue gases generated during the combustion of all types of fuels, is, under certain conditions, a powerful scaler.

The ideal atmosphere for annealing, normalizing, drawing, box carburization and preheating in furnaces of the semi-muffle type or in furnaces where the combustion takes place in contact with the work, is a neutral atmosphere, or one which contains a trace of free oxygen. This condition is one which is difficult to guarantee at all times. Therefore, to minimize the harmful effects of flue gas on exposed surfaces it is necessary to establish positive circulation in the furnace. The area of the flues should also be so arranged that a back pressure is constantly maintained which will not allow the infiltration of any excessive air into the furnace interior.

It is possible to improve the operating efficiency of a fuel fired furnace by using a large number of small burners rather than by using only a few. The burners should be staggered on either side of the furnace, and in small muffle and semi-muffle furnaces the burners should fire below the hearth. In certain larger furnaces the burners may be staggered and placed at the top of the furnace near the crown of the arch. In even larger furnaces of the car type, some burners should be placed so as to fire under the hearth and others over the work.

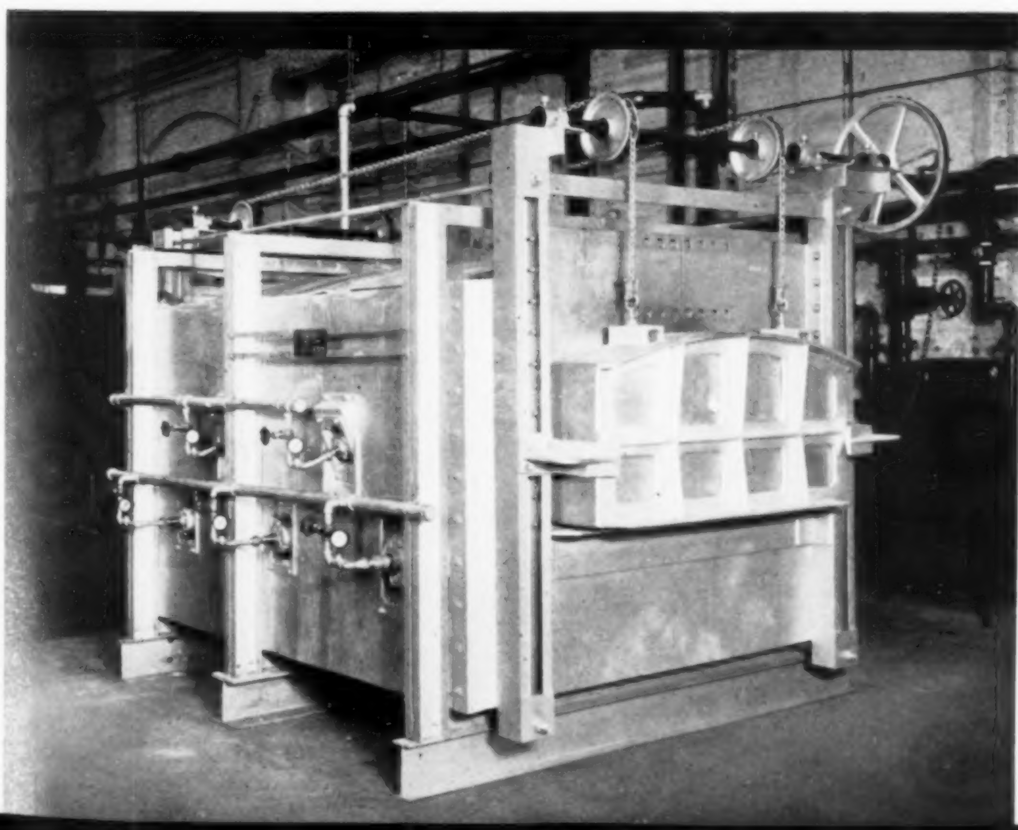
To control combustion, it is essential to select burners which will produce and maintain definite proportioning of the gaseous fuel and the air over long periods of time. The ideal combustion mixture, as far as atmosphere is concerned, is very nearly the theoretical ratio of gas to air for perfect combustion. It may be remarked in passing that air and gas burners with two controlled valves can not secure controlled furnace atmospheres in the sense used above.

A test was recently conducted on a large car-type furnace, which at the time was used for carburization and equipped with two-valve burners. After the volatile constituents of the carburizing materials were driven off, analyses of the flue gas, taken from three zones, demonstrated the phenomena of delayed combustion. A zone some six inches above the gas burners showed an excess of free oxygen, the middle of the furnace contained considerably less free oxygen, while the upper samples from near the arch showed a neutral atmosphere. Conditions existing in this furnace made uniform temperature distribution impossible and introduced conditions which produced variations in the properties of the materials treated.

The use of electrical resistors which generate heat directly in the furnace compartment produces an ideal atmosphere for many of the heat treating operations. If an electrical furnace is air tight the amount of free oxygen in the furnace will not produce excessive scale or cause appreciable decarburization. To insure proper atmospheres, the newer types of electrical furnaces are equipped with devices which introduce raw gas or some inert gas above the surfaces of the metals treated.

While the whole subject of atmosphere control is so broad that only a few of its aspects have been lightly touched upon in the foregoing article, it is evident that the trend of the times is toward a realization of its importance. Instances of it range all the way from the ancient patenting furnaces, where the rod is drawn through a gas filled pipe and exits directly into a molten lead quench, to the modern continuous furnaces which include a quench tank as an integral part. Improvement in scale resistant metals and high grade refractories is giving added impetus to the study of semi- or completely muffled furnaces. Metallurgical operations which definitely produce correct atmospheres for carburizing, brazing, or bright annealing are quite common.

Altogether the production executive has a number of alternatives and his decision, of course, should rest on those furnaces which will give the desired results at the lowest costs.



Courtesy Ludlum Steel Co. *Photograph by Margaret Bourke-White*

Good Steel Starts At the Ingot

Win or Lose . . .

Now That The Fall months are here, and the national convention of the Society has been held, the officers of the various Chapters are looking ahead with high anticipation to the monthly meetings of their own groups. In nearly every locality, the executive committee and the program committee have had periodic meetings, and the subjects for discussion and speakers are already fixed for several months to come. In all likelihood such a course, planned in advance by your own members, will include those subjects which are of most interest at the moment to the entire membership of the chapters, comprising a series of discussions of everyday problems, and will constitute an educational program which can be duplicated in no other way.

It is the privilege of every member of the American Society for Steel Treating to enjoy and profit by these meetings. If he attends regularly, mixes with those present, becomes acquainted with the men who are in the same line of work, he will enjoy himself. He will profit by an interchange of ideas, informally in conversation with his new acquaintances, and also in the more formal part of the program, when listening to the speaker of the evening, and joining in the discussion.

It is his own loss if he does not take what is rightfully his. It is his Society's loss if he does not give a little of his time and experience to his fellow members. If he attends, everyone gains. If he stays away, everyone loses.

Each man should give a little of his time to the advancement of his art, his profession or his industry.

Casting vs. Welding . . .

An English Engineer recently remarked that aircraft engine construction in his country did not get a start until the middle of the war, when the demands of Imperial defense jarred the manufacturers loose from cast iron, "that material which had served their ancestors so long and so well for lamp posts, sad irons and kitchen stoves."

In America we pride ourselves with being more adaptable, more able to select something new which serves the purpose. For that reason, our foundry industry has been fighting competition from forgings, stampings, die castings, molded compositions and welded steel shapes and plates. By and large, the foundry industry has hardly held its own.

Of course there are exceptional organizations and plants in gray iron, brass, steel and malleable, which have been able to expand and prosper. But taken as a whole, statistics show that the output from merchant furnaces — roughly representing foundry iron — is making a sorry showing when compared to the total blast furnace pig iron. Likewise, the steel foundry industry, greatly over-expanded during the war, has ever since been struggling to get business in a satisfactory volume. Many weaker companies have been bankrupted; the more ably managed companies, by sound management and a proper appreciation of scientific research, have supplied the lion's share of the existing demand.

Is the volume of this available business to be further restricted? How many parts will be made of welded steel rather than steel castings?

This question has been discussed many times. A new approach is used by Messrs. Namack and Hobart in an article in this issue. Their thesis is that the steel foundry should not attempt to make big castings; it should make little castings and then weld them (with plates and shapes as needed) into big pieces.

Such a method of approach tacitly assumes that steel founding is an uneconomic method for bulky, intricate or rangy pieces. This corresponds to the trend in manufacturing large electric generators, with which the authors are most familiar. General Electric has so universally substituted rolled and welded steel that a casting weighing more than a few hundred pounds is as rarely found in its plants as a horse and buggy.

It seems, however, that the criterion is not *size*, but number. If only a few pieces are to be made, welded steel will always compete. If the quantity is sufficient so that the foundry can

install appropriate molding machines, conveyors and other labor saving devices and operate them steadily, then the casting method will be more economical for large as well as small castings. This fact also, while not definitely stated, is implicity recognized in many parts of Messrs. Namack and Hobart's article — rather than a few large parts, make *many* smaller ones, they say.

Another editorial comment may not be amiss: Within the last few months two very interesting applications of welded plate have been observed. In both instances the parts formerly used were steel castings, and represented sizable business and good prices. In both instances the substitution was forced, against the desires of the consumer, because of the difficulty (if not utter impossibility) of getting castings free from internal sponginess and blowholes and external pits. The substitution was made not without expensive experience with unsuitable welds, but now that this problem has been solved, so many collateral advantages have been found to reside in welded construction that the steel casting is definitely out of the picture.

Since steel castings have been exploited preeminently as a quality product, such incidents as these are worthy of careful consideration by the industry. Forgings have definitely secured the upper hand in high pressure pipe fittings, valve bodies, and such like because they are not so liable to develop a leak under test and cause expensive and extensive replacement. Are castings destined for further discrimination by purchasers who are not interested in high pressure work but who expect to get sound metal, sound underneath the skin, when they are sold a "quality" product?

Convention Bills . . .

Those of Us who were fortunate enough to be able to spend the last week in September at Chicago retain the liveliest recollections of a week well spent. If one were to count the money and time required to visit each one of the men or organizations who contributed to the information acquired during a short five days, the sum would make the actual expense account seem trifling by comparison. If those who pay the bills could have this thought emphasized to them, and if they could realize how few go to a National Metal Congress with the idea it is a vacation, the expense would look like an investment.

An Essay on Quality . . .

Metal Progress, the term, tacitly implies that progress in metal will ordinarily be associated with improvement in quality. "Quality First" would be the slogan, if it were guaranteed that the word quality might not be misinterpreted. It means different things in different connections.

A manufacturer would be foolish, for instance, to put electric or crucible steel into fencing, yet very wise to use it for hoisting cable. The qualities in steel wire which make it suitable for easy twisting and weaving and for withstanding atmospheric corrosion are quite different from those which enable it to resist shocks, overload, and constant bending over sheave wheels.

When the word quality is understood as Webster defines it: "Excellence of character; a natural superiority in kind," the phrase "Quality First" is full of meaning. Some firms and some whole industries have worked to this ideal and have thereby established a reputation for superiority. Undoubtedly such a situation is responsible for the wide use of American tools in German machine shops, and for the fact that the German salesman, soliciting an export order, is likely to say that his goods "are just as good as Brown & Sharpe."

To attain such an enviable reputation and yet to be a commercial success requires that the urge of idealism be checked by the practical rein of expediency. For instance, to make an excellent micrometer it is not necessary to pickle the forged jaw in chemically pure acid, or polish the barrel with diamond dust. That expense might far better be put into the lead screw and the dividing engine.

In other words, the commercial problems to

be solved when arriving at a superior product have to do with the balance between absolute excellence and the expediency of the proposed line of action or the actual necessities of the construction.

Those who can make the best approximation to this balance are frequently found to be the pioneers in the industry, and are the leaders in the manufacture of a product superior to those of its kind. Metal progress for such men will mean the production of a part which better serves the purpose for which it is intended. It will be the summation of a thousand details, each one carefully planned in relation to the entire course of manufacture, from the raw material to the finished article, ready for sale.

Machinability . . .

Is THE PROBLEM which is now worrying many men who have to do with mass production in metal. Wherever they foregather, it is a safe bet that before long they will be comparing notes on recent machining experiences. It reminds one of that perennial topic of conversation some ten years ago: The ability of some sheets to stand deep drawing and of others (almost indistinguishable) which failed miserably in the same dies.

Producers of metals and alloys have in prospect yet another requirement added to the specifications, written or understood, which they must meet. It is not enough that the metal must be sound, inside and outside, with correct chemical analysis enabling it to be heat treated to certain strength and hardness, have proper grain size and normality — all this is not enough, but now the steel must be uniform, heat to heat, in its machinability.

Such a requirement is the more difficult to meet, since there is no ready test for the property desired.

Of course, we all know there are variations in the ease with which metal may be cut, ranging all the way from screw machine stock to the austenitic manganese steels and aluminum bronzes. But there has not yet been established any *quantitative* measure. Frederick W. Taylor showed how it could be done, and actually did it more than 30 years ago, when he was reducing the art of cutting metals to a science, but the theoretically correct way is so time-consuming and so expensive that the work is seldom performed today, and in any event is impracticable as a routine acceptance test.

Meanwhile, the purchaser is faced with the circumstance that one heat of steel, identical with its predecessor as far as chemical analysis, cleanliness, hardness, grain size, normality and tensile properties can determine, acts quite differently when on a gear cutter. Tools must be ground five times as often, to the general disruption of production schedules and boosting of production costs.

Some consumers have the attitude that since this is something which is inherent in the steel, it is a problem for the steel maker to lick. Others are studying it intensively to discover some criterion which will quickly spot a steel which is hard to machine.

Most steel makers are inclined to say that it is unfair to expect them to meet an intangible specification.

The outside observer is reminded of the situation of "armed neutrality" which existed years ago between the sheet manufacturers and the auto body builders, until it occurred to some of them that *neither* consumer nor producer could produce deep drawing stock without the other's help. When the production men of both parties met, told each other about the difficulties and requirements, agreed upon a campaign whereby the effect of each variation in commercial practice could be tested in turn, then real progress was made.

This does not imply that there are no troubles to be encountered in the manufacture and use of fender stock, for instance, yet it is true that the quality of the sheet now commonly sold under this classification is far and away better than it was when the two parties were passing the buck back and forth. But it does imply that this new problem of uniform machinability will progress toward solution at a speed directly proportional to the amount of cooperative investigation which is done by steel maker and steel buyer.

According to the New Publication Policy of the American Society for Steel Treating, TRANSACTIONS *will appear twice a year. Its principal contents will be papers presented before general meetings of the Society, together with the discussion. An important additional class of material will be articles on metallurgical theory or exhaustive discussions of problems which are worthy of permanent record but which are not adaptable for presentation at length in* METAL PROGRESS.

Such an instance is a study of "Austenite Decomposition and the Changes in Magnetic Properties," by H. S. Van Vleet, metallurgist, Western Electric Co., Chicago, and Prof. Clair Upthegrove, University of Michigan, an abstract of which is presented herewith. Reprints of the entire article in pamphlet form will be sent to those members of the A. S. S. T. who send a request to the National Office.

Decomposition of Austenite

WHILE austenite is retained in quenched steel and is non-magnetic in character, it is possible that there is a critical amount existing in heat treated tungsten steel which for each composition yields the maximum magnetic permanence. To investigate this supposition Messrs. Van Vleet and Upthegrove quenched a steel containing 5.7 per cent tungsten and 0.60 per cent carbon from various temperatures in oil, water and sodium hydrate, and then measured the hardness, density and magnetic properties after tempering at several heats and after immersing in liquid air for various periods.

During the last 15 years, many studies have been made on the preservation of austenite in quenched steels and its subsequent decomposition. A summary of the main conclusions of these researches may be stated briefly as follows:

1. Austenite is shown by the method of X-ray spectrum analysis to be a solid solution of carbon or iron carbide in gamma iron.

2. Austenite is always present with martensite in medium or high carbon steels quenched from the normal hardening temperatures.

3. Higher quenching temperatures generally favor the retention of a greater proportion of austenite.

4. The presence of certain alloying elements favors the retention of austenite at room temperatures in quenched steels.

5. Quenching in oil retains a larger proportion of austenite than quenching in either water or 5 per cent sodium hydroxide.

6. Gamma iron and austenite are non-magnetic in character.

7. Retained austenite shows a marked difference in stability upon immersing the quenched steels in liquid air. In carbon steels, liquid air immersion causes practically complete decomposition of retained austenite. In alloy steels no definite statement applies.

8. Austenite decomposition in liquid air causes the formation of martensite.

9. Austenite decomposition by tempering usually produces troostite.

10. When austenite is made to decompose on tempering, the temperature range most favorable for decomposition is dependent on the alloying elements present and their concentration. Time of heating at temperature plays an important part in the decomposition of austenite during tempering. A long draw at a low temperature will cause the same effect as a shorter time at a higher temperature.

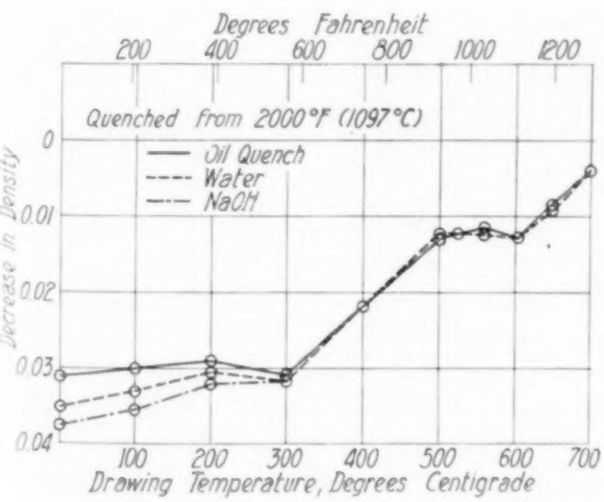
11. In the tempering of quenched carbon steels, there are two processes which take place: first, the decomposition of martensite taking place over a wide range of temperature, beginning at a tempering temperature of 100 deg. C. and continuing until 400 deg. C. is reached; and second, the decomposition of austenite which takes place over a shorter interval of temperature, starting at approximately 150 deg. C. and ending before a tempering temperature of 300 deg. C. is reached.

12. Austenite retained in quenched steels is rendered less stable by deformation.

Hardness of Constituents

The scratch hardness of the various constituents of hardened and tempered steel varies in decreasing order as follows: martensite, troostite, austenite, sorbite, pearlite, ferrite.

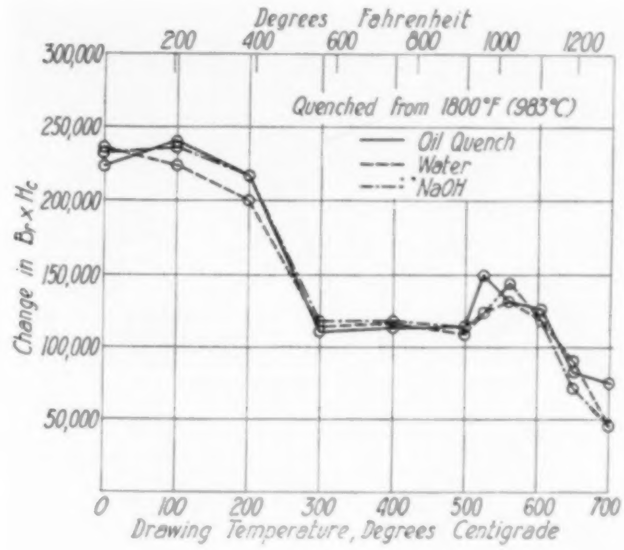
14. The density of the various constituents of steel are given in order of decreasing density or increasing volume: carbides, austenite, ferrite plus carbide, and martensite.



Changes in Density of Quenched Magnet Steel After Various Draws.

Typical results of Van Vleet and Upthegrove's experiments are shown in the selected curves on this page.

Three distinct changes in slope of the curves in the first diagram were found common for all quenching temperatures from 1600 to 2000 deg. Fahr., viz. at 300, at 525, and at 605 deg. C. These changes in slope of the curves representing changes in density with tempering temperature may be attributed to the separate or combined influence of the following factors:



Changes in the Product of Residual Induction by the Coercive Force with the Drawing Temperature.

1. Release of quenching stress and distortion of the space lattice, resulting in an expansion in volume or a decrease in density.

2. Precipitation and coalescence of carbide particles resulting in a contraction in volume or an increase in density.

3. Decomposition of martensite causing a contraction in volume or an increase in density.

4. Decomposition of austenite causing an expansion in volume or a decrease in density.

The increase in density which occurs upon tempering up to 200 deg. C. is probably a result of the predominant influence of the second factor, precipitation and coalescence of cementite particles.

Differences in density between specimens quenched in oil, water and 5 per cent NaOH disappear when the drawing temperature reaches 300 deg. C. This is believed to be a result of relieving those differences which arose during the quenching treatment; namely, dif-

ferences in stability and amount of retained austenite, differences in quenching stress and in amount of ferrite and cementite particles.

In tempering above 300 deg. C. the change in density is a uniform increase, showing the predominance of the third factor, resulting in a uniform growth of ferrite particles and martensite decomposition, until 525 is reached.

Factors Counterbalance

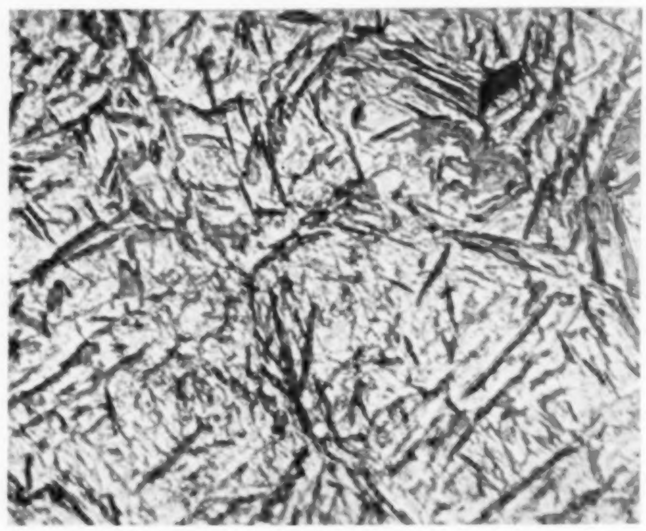
In tempering the quenched bars between 525 deg. C. and 605 deg. C. the density remains practically constant. This evidence points to the conclusion that the retained austenite decomposes during tempering within this temperature range and that the decomposition of martensite and austenite, factors (3) and (4), proceeds at rates which counterbalance each other, as indicated by the small net change in density over this range of temperature. In tempering above 605 deg. C. the slope of the curves, which represents the change in density with tempering temperature, is approximately the same as the slope below 525 deg. C. This supports the view that martensite is a product of the decomposition of austenite during tempering and that the changes occuring in the magnet steel upon tempering are the same immediately above the range of temperature most favorable to the decomposition of austenite as immediately below that range.

Corresponding changes in magnetic properties are most clearly noted in the second diagram.

Similar experiments were made on bars after immersion in liquid air. The authors conclude from the data that such immersion is not sufficient to decompose completely the austenite retained in 5.7 per cent tungsten steel, especially when quenched from the higher temperatures. Also that the decomposition product resulting from a liquid air quench is different from that resulting from a mild tempering. For instance, while both treatments increase the density, the Rockwell C hardness is increased by drawing but decreased by liquid air immersion. Furthermore, while the residual inductance is increased by both treatments, the coercive force is increased by drawing but decreased by liquid air immersion.

The authors explain such facts by reference to the mode of decomposition on the effectiveness of the four factors outlined above. When austenite decomposes during tempering the stresses set up within the specimens by quenching are relieved. In tempering decomposition proceeds more slowly, giving time for the precipitation of cementite along the crystallographic planes and subsequent coalescence of the particles. During tempering the growth of ferrite particles also takes place as the temperature is increased, and the decomposition of martensite and troostite accompanies the decomposition of austenite during tempering within the range 525 deg C. to 605 deg. C.

On the other hand, when the retained austenite decomposes during immersion in liquid air



Structure of Magnet Steel After Quenching from 1100 Deg. C. in Oil. Magnification 1000 X.

the quenching stresses are still present and the coalescence of cementite and growth of ferrite particles is impeded by the low temperature. The rate of decomposition of austenite is rapid during immersion in liquid air, as indicated by the greater part of the total change taking place within the first eight hour period of immersion.

The observed differences in effect of austenite decomposition, depending on whether the decomposition is affected by liquid air immersion or by tempering, are therefore believed to be the result of the mode of decomposition. Decomposition during tempering follows the austenite-martensite-troostite-sorbite type of change while in liquid air the decomposition simulated the austenite-troostite change without the accompanying growth of cementite and ferrite.

Welding .

Photograph Courtesy Stoody Co.

is it a help or a hindrance in the Steel Foundry

IT IS SAID in a recently published article that "modern chemistry is rejuvenating long-established industries and creating new ones over night." Yet it is not alone in chemistry but in many other fields of applied science that knowledge is advancing at a rapid rate and new processes are being applied not only to create new industries but to perfect and advance the long-established ones.

Modern welding processes constitute notable instances. Among the industries in which welding is already being employed with much advantage may be mentioned (1) steel building construction (2) steel bridge construction (3) ship building (4) pipe line construction (5) construction of various kinds of machinery such as machine tools, electric motors, generators, transformers, and switchgear, and (6) construction of pressure vessels.

There has been some feeling that the continually increasing use of welding is a menace to the steel foundry. To this we do not agree. The object of this paper is to call attention to the value of combining the accumulated experi-

ence in the foundry and in the welding arts, and of applying this united experience to the development of the foundry art to a degree hitherto unattainable.

The suggestion that the steel foundry has seen its best days is preposterous. Nevertheless, not only are such suggestions made or implied, but there is an inclination to take ill-considered steps in anticipation of a decreasing need for cast steel products. We read numerous articles which express pessimistic views of the future of the industry. Among reasons mentioned for the dismal outlook is the rapidly increasing substitution of welded rolled material for steel castings. Instead of being regarded as a menace, our contention is that welding processes should be considered as a logical complement to the foundry art.

By I. H. Namack and H. C. Hobart

Why, Ask the Authors, Should Structural Details Be Made of a Dozen Small Parts, Riveted Together, When a Single Steel Casting, Welded On, Is Better

It is very true that during the last few years many kinds of dynamo-electric machinery have been redesigned, the castings employed in the former designs being largely (and often entirely) replaced by rolled material joined by arc welding. In the manufacture of machine tools and of other products, corresponding changes have been made. Yet our contention is that engineers have yet failed to take full advantage of designs whereby two or more component steel castings may be joined by arc welding (or, indeed, by any kind of welding) to make up larger parts. Similarly, steel castings are only infrequently welded to rolled plates and structural shapes. Why, for instance, should a structural engineer continue to make brackets of plates and angles, the same as when nothing but riveted joints were permitted? Simple, standardized castings, readily welded to a column by an operation such as shown in the striking photograph at the head of this article, would be a better detail.

For foundries with open-hearth furnaces, the cost of molten steel is a little over one cent a pound, but the further steps of producing castings bring up the cost to 10¢ or more for complicated products or 5 to 6¢ per lb. for those of simple design.

Now numbers of simple and cheap steel castings, properly joined by arc welding, will be as satisfactory as the usual single casting of steel. An instance of this is shown on this page, photographed by Stoody Co. of Whittier, Calif. An oil drilling fixture, subject to the severest service, is most efficiently made of two simple castings welded to each other.

We have also in mind even larger and more intricate fabrications. In some cases the complications of making the product with a single casting and the limitations of the foundry processes, will result in a greater weight for the required duty than would be the case with an equivalent structure made up from two or more simple components, each devoid of expensive complications, welded together. For instance, the designer must keep the cross-sections in his casting as nearly uniform as possible, regardless of the strength requirements. Or he must make certain sections extra heavy to provide proper feeding and to minimize shrinkage stresses.

Assume a single complicated casting weighing 1000 lb. and costing 10¢ per lb., or $100. One equally good may be produced by welding together several simple castings costing, perhaps, only 6¢ per lb.; and, owing to the above con-

siderations, it may have a total weight of only 800 lb., the total cost of the component castings thus being $48. It can be reasonably assumed that the cost of joining the component castings by arc welding is $16. Then the total costs will be $100 and $64 respectively. The total weight has been reduced by 20 per cent and the total cost by 36 per cent.

Unquestionably there are many instances where, at the lesser cost, a lighter and better product will be obtained. Also, artistic appearance can be given more consideration, utilizing castings for the rounded or filleted regions, and plates for the flat areas.

Go even further to the matter of large castings weighing many tons. The practice of arc welding has now reached the stage where satisfactorily high strength may be obtained by welding together any number of castings of whatever size and shape correspond to the lowest cost. It is in the very large castings that there is the greatest probability of blowholes, sponginess, and other defects, and in which the cost and delay of rejections are most serious.

Also the small components can frequently be machined on less expensive tools, several at the same time, and not welded together until all or a great part of the machine work is done. There is thus the hazard of rejecting only a relatively small part in the event any defect is uncovered. The time required to build massive machines may by this procedure be decreased considerably.

A large casting embodying many projections or changing contours involves a pattern which must be so molded that the important factors for success, such as drawing of the pattern and position of the gate and feeding heads, are at best compromises. As a result certain parts of the casting must necessarily suffer. If, instead of the large castings, we make the piece out of component castings, then each part may be so molded and poured as to obtain the best results.

The proposed procedure eliminates large and expensive cores, and avoids many associated difficulties. The cost of cleaning and chipping will be reduced. There will be fewer fins at the joining of core to core and to mold. All parts of the individual parts will be more accessible for cleaning.

Foundry troubles traceable to maintaining cores in proper position using "tie downs" to prevent floating, or chaplets for support, will of course be minimized.

Another source of cost with large steel castings is the number of massive shrink heads and provision for their removal. Shrinkage tendencies also constitute very much less of a difficulty in small than in large castings. Furthermore, greater uniformity of composition may be obtained more readily in small castings, which cool more quickly.

Various desirable heat treatments can be applied to small castings, and much more cheaply and effectively than to very large castings. The employment of hydraulic pressure and also of centrifugal methods during the process of casting, to improve the casting, is more practicable and effective in small castings than in large ones.

Lastly, in the case of very large structures, shipping may be facilitated and cheapened by welding together only the small components into moderately large parts. These moderately large parts may be welded together on the site.

Should Reduce Foundry Overhead

The kind of welding contemplated in these recommendations is so ordinary and is already so well-developed that, if taken over by a foundry, it would add but little to the burden on the executives. In other words, the foundry would continue to be a foundry, the welding work being a minor detail, though one of much importance in enabling the foundry to compete with concerns turning out fabricated structures.

A new foundry would be designed to produce individual steel castings up to a certain reasonable size as a maximum. This would decrease the cost of the building and its equipment, thus decreasing the fixed charges.

Perhaps the proposal may be made more definite by suggesting that essentially it consists in substituting for an outlay of 100 for a steel foundry of the traditional design for making castings up to a limiting weight of pounds, a foundry equipped for making castings up to a limiting weight of only (say) one fourth of P pounds and only costing 50 instead of 100, together with the provision of welding and machining facilities costing 10. With such a foundry, the overhead would be figured on a capital outlay of 60 as against 100.

In arriving at the correct economic distribution of the work between the fabricating departments and the foundries, more consideration should be given to the possible and desirable use of welding for joining mild steel castings to each other, to rolled plates, to structural sections, to forgings, or to metal stampings. Proper allocation of these details will, in all probability, prove to be as important a consideration in the layout of a new plant, as they would be, for instance, in a new shop for the fabrication of structural steel.

These suggestions apply *exclusively* to cast steel, and not to cast iron. Welding of cast iron parts is at present usually attended with complications and difficulties. Undoubtedly, however, the merits of the plan will often justify using cast steel where heretofore cast iron has been employed.

This general proposition naturally leads to the possibilities of standardization and simplification of patterns and castings. In some parts of machines of very different kinds, sizes and purposes, the same castings could be employed, suitably welded to other standardized castings, rolled shapes, forgings, or metal stampings, to obtain very different resultant structures.

In addition to the lists of rolled shapes of standardized dimensions to which designers constantly refer in their work, there should gradually be accumulated lists of simple castings for purposes requiring their use in large numbers and which would be cheaply produced in large quantities. Such a movement has already started. Thus, in the June 1930 issue of *Valve World*, the Crane Co. illustrates a standardized line of forged steel flanges with necks ready to be welded to piping of standard sizes.

The illustration on the preceding page gives an instance where steel castings are being welded to other steel parts. It was photographed at the Bauer Brothers Co. plant, Springfield, Ohio. The part is the base of a hammer mill for grinding grain and other organic products. The welder has one such base practically completed. Components for a second are ranged in the foreground.

The two sides are steel castings, and incorporate brackets, bosses and channels. It could have been made of steel plate, but would have cost too much. The entire box-like structure, with flat ends and curved hopper bottom, can be most readily fabricated by a judicious combination of rolled and cast steel into a rugged part of minimum weight and cost.

Progress is made infrequently by discarding entirely an old and well tried process — rather by fostering and developing its unique or superior merits. Welding, the process, is relatively new and has fired the enthusiasm of its proponents to accomplish many notable advances. However, although we are among the proponents of welding, we would plead for a broader view of the question "casting vs. rolled product." Each has its place. Each has its unique merits. A judicious combination of cast, rolled and welded products will undoubtedly represent the most economic solution.

The Enterprise . .

A Metal Yacht

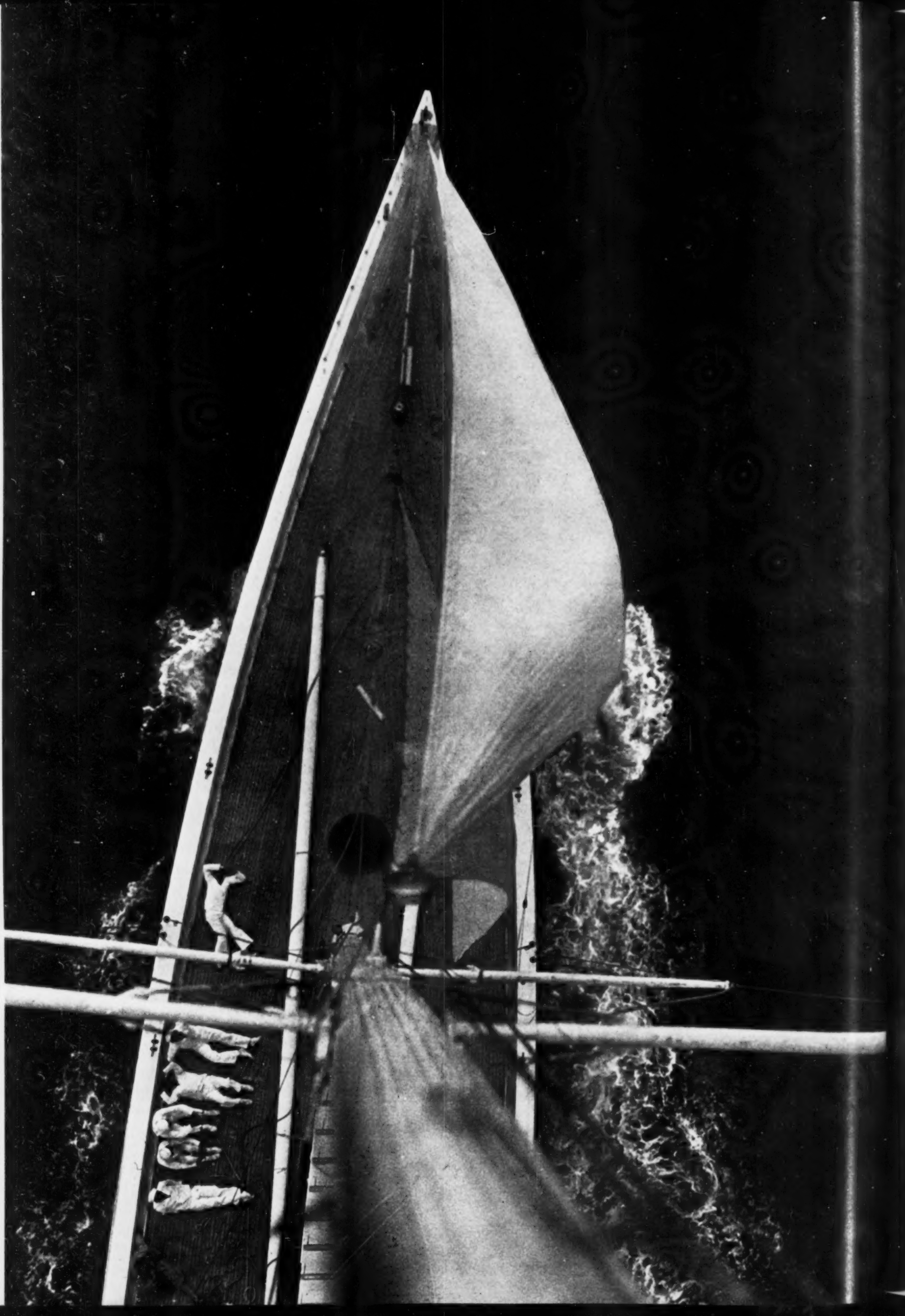
A WESTERNER, whose youthful races were run on the hurricane deck of a cow pony, would assume that the rigging of a cup defender is made of stuff like a lariat. Even an easterner who is more used to regattas might readily think that a racing yacht is made of canvas, hemp and wood. As a matter of fact, both are wrong.

Small boats *are* made of wood, but the ships of 75-ft. rating and bigger, capable of sailing the ocean, are mostly metal and canvas. Bronze hulls are an old story, dating back 30 years to the Reliance, which defended the cup in 1903, but W. Starling Burgess, of New York, designer of the present defender, the Enterprise, has carried the matter still further with a duralumin mast, super-strength steel cable socketed in heat treated alloy steel fittings, and a variety of gear made of other metals and alloys.

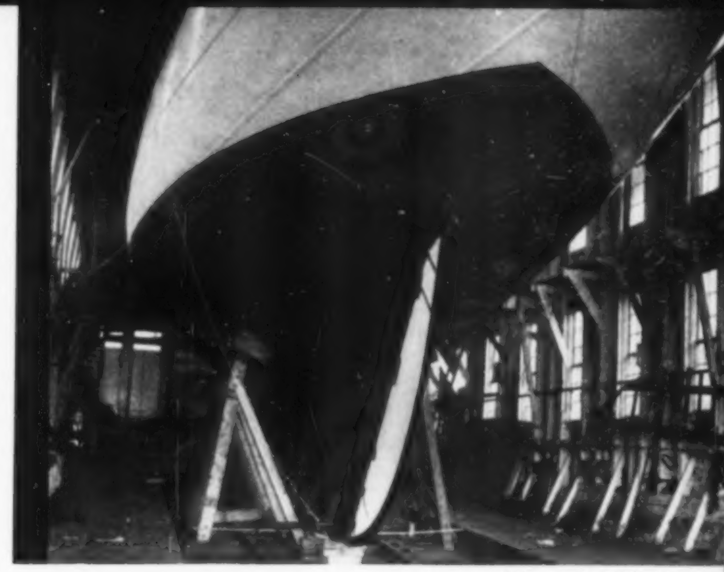
Everyone who reads sporting news knows that four yachts have been built during the last year to compete for the honor of defending the America's cup. Of these, three (Yankee, Enterprise and Weetamoe) are constructed of steel frames and deck beams, bronze shell plating and wooden decks. The fourth, the Whirlwind, as well as Sir Thomas Lipton's challenger, Shamrock V, is built on the composite system, with steel frames and mahogany planking. All five are designed under the so-called universal rule of rating, 76-ft. class, so they may race on equal terms without time allowances or handicaps based on variations in hull dimension and sail area. All meet Lloyd's requirements for scantlings and details of construction, and, consequently, are sturdy craft able to withstand rough weather in open seas.

Two of the views (over-page) show the exterior and interior construction of the Enterprise's hull, which may be regarded as typical. The steel frames made of bulb angles are set fairly close together, so the $\frac{1}{4}$-in. tobin bronze plating may ride unsupported between. Plates are joined with $1\frac{3}{4}$-in. single lap at longitudinal seams, and butted with interior straps at transverse joints. (In the Yankee and Weetamoe hulls the longitudinal seams also are butted joints with inside straps, a somewhat heavier design.) Rivets are also of tobin bronze, $\frac{1}{2}$-in. diameter, with countersunk heads outside.

From the exterior view it can be seen that the upper hull is painted, but below water line the bronze plating is hand rubbed to a brilliantly smooth polish. This is to reduce the skin friction, when rushing through the water, to the very minimum. In fact, the 80 tons of lead, forming the Enterprise's keel, the rudder and all underwater parts are sheathed with polished tobin bronze. A low coefficient of friction, and



superior resistance to fouling from corrosion products or marine growth, are two factors which make polished bronze much superior to painted steel for hull plating. The view of the hull, at the right, shows by the mirror-like reflections from the plating that it is possible to lay it on the hull in fair lines. Whether bronze is sufficiently better than mahogany to warrant its excess weight was debatable when the yacht was built, but the result of the races has removed this doubt.



Photos by Edwin Levi

A question will immediately arise in many readers' minds: "How about corrosion of the steel frame?" They remember that a monel metal yacht, Sea Call, was in the water only three weeks when the iron rivets began to drop out, the heads entirely eaten away by corrosion. A perfect electrolytic cell was established by iron, copper and sea water, all three in intimate contact.

The reply is that in the Enterprise all exposed metal is of one analysis — tobin bronze. The bronze-to-steel contacts are all *inside* the hull, where it is dry. Of course, a little leakage is unavoidable. It will wet the flat keel plate and angle bars joining the keel to the lowest course of hull plates. These parts are all of bronze, the steel frames being stopped several inches above, giving a clear trough in which the bilge water can slop about. Thus there is little likelihood that steel and bronze can be long submerged in salt water.

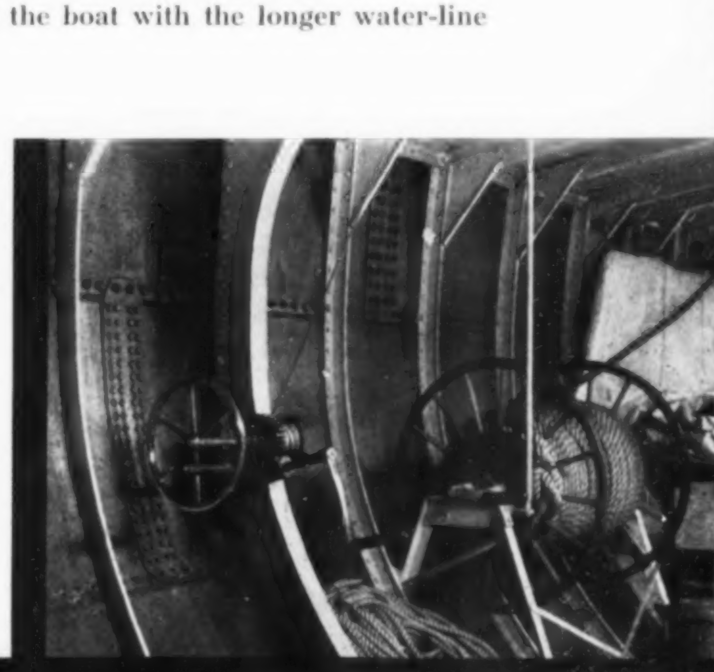
Experience also indicates that these precautions are sufficient. As remarked before, the Reliance, built in 1903, has a steel frame and bronze plating on the hull and an aluminum deck. This boat was refurnished sumptuously as a pleasure yacht after its successful defense of the cup, and has been in commission since then. Indeed, the Resolute, built in 1914 in this manner, was used as a trial horse in the elimination races last summer. Hull and framing of both boats are in perfect condition.

Before leaving this very interesting matter of hull construction, it may be mentioned that the wooden planking of the Whirlwind is attached to the steel frame with everdur bolts, set in countersunk holes, plugged from the outside with wood.

Several times in the above account the matter of saving in weight has been mentioned. It might be assumed that the lightest boat would sail the fastest. This is by no means true. In the trial races the Yankee, with 145 tons displacement, several times beat the Enterprise, weighing 16 tons less, in a strong breeze. Their sail areas are identical. It seems to be a matter of *where* the weight is placed, the shape of the hull, and the margin of strength in the rigging to withstand a real wind.

It is difficult to expound this matter of saving weight where weight counts, without dragging integral calculus and complicated formulas into the discussion. It will readily be seen that a smaller boat with less wetted surface to offer skin friction and less wave-making resistance will be superior to the heavier boat (as far as speed and sailing ability is concerned) if she has the same righting moment to hold her up to the wind. But this righting moment depends directly on the displacement; the heavier boat, if reasonably well designed, has inherently a better righting moment and this counteracts, in part, the advantage of the lighter boat.

Furthermore, water line length has so much to do with it, that the requirements of the rules fix the relationship between it and the displacement. The longer boat must be heavier, and thereby have a bigger stability moment, and better ability to stand up in a breeze. This advantage of the boat with the longer water-line



Duralumin Mast, Steel Cable, Alloy Steel Spreaders and Cable Ends, Brass and Monel Fittings

length may be overcome by a slightly shorter and lighter yacht by cutting down the weight of her rigging, thus creating a boat of the same driving power yet meeting less resistance from the water.

Stripped of many technical qualifications, it may be said that the heavier ship requires more sail to drive her through the water. But the gross dimensions of hull and sail are fixed for the cup races within fairly close limits by the qualifying rules. It follows that, sail area and stability being equal, the lighter ship will ride higher, meet less resistance from the water, and turn the available sail power into speed more efficiently.

Bear in mind that the center of gravity of the mast, sails and rigging is about 60 ft. above the center of gravity of the full-rigged craft. The center of gravity of the lead keel, on the other hand, is only 10 ft. below the center of gravity of the whole ship, mast and sails. It follows that every pound which can be dropped out of the rigging, and placed in the lead keel represents a valuable increase in stability.

Furthermore, a sailing ship with light rigging handles more smartly than one with heavy; there is less momentum on the moving parts, keeled over by a puff of wind, and the counteracting force exerted by the ballast pulls the mast back toward plumb more quickly.

Mr. Burgess, designer of the Enterprise, therefore turned his attention to saving weight where weight counts the most. The first mast used by the Enterprise was built of spruce into a thick-walled oval, 27 by 20 in. in major dimensions, 168 ft. high. It had monel metal fittings and weighed about 5100 lbs. A spare mast was also built, with slightly thinner walls and many duralumin fittings, saving 300 lb. Riveted duralumin was then considered. A third mast of equal strength was built of this metal with many heat treated chrome-molybdenum and stainless steel details by the Glenn L. Martin Co., Baltimore, Md., and it weighed only 4000 lb. (All figures are for "naked" mast, without fittings).

According to Henry Gruber, chief draftsman for the Burgess firm, a further 600 lb. was saved in the fittings about the mast, and 800 lb. more by using high strength steel cable, "tru-loc" shroud ends and duralumin blocks instead of more conventional materials. This makes a total of approximately 2500 lb. saved 60 ft. aloft.

The Enterprise actually has 15 long tons less displacement than the Weetamoe, the lightest competitor, and 6 long tons less than the Shamrock, of almost identical dimensions.

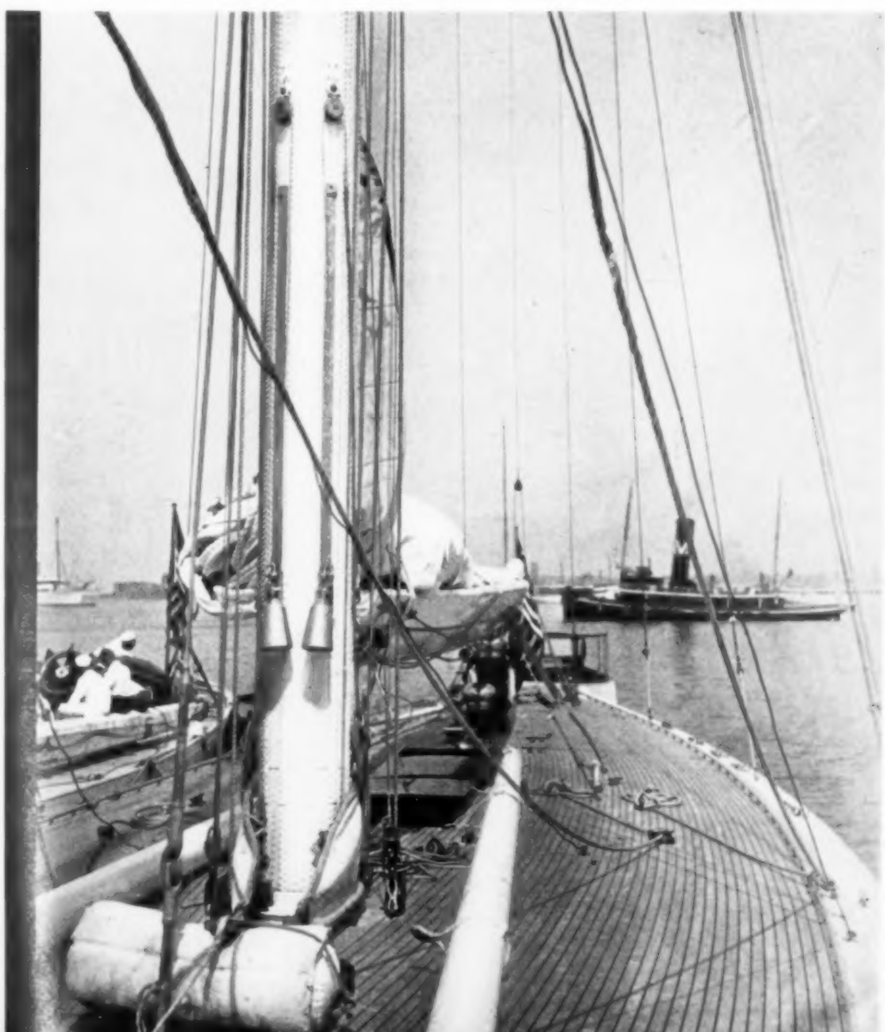
A good idea of the construction of the duralumin mast may be had from the illustration on page 79. Its cross section is a 12-sided regular polygon, 18 in. outside diameter at the foot, tapering toward the top. The normal thickness

of the wall consists of two $\frac{3}{16}$-in. plates (three in the bottom section), and a bent angle plate inside and outside at each corner. All rivets are duralumin. It is stepped — that is, fixed in a socket at the keel — in the very fusible Wood's metal (50 per cent bismuth, 12.5 per cent tin, 25 per cent lead and 12.5 per cent cadmium).

Views on page 80 of fittings on the light wooden mast show the difficulty of transferring stress from mast to steel shrouds. Spruce is quite weak in bearing, across grain, consequently the loads must be spread out to a number of wood screws in the wooden mast by monel metal tangs. The equivalent attachments to the duralumin mast are made to a pin extending clear through the mast. At such a point short lengths of the light metal strapping on opposite sides are replaced with heat treated chrome-molybdenum steel, through which is let the pin, a piece of $\frac{3}{4}$-in. Shelby seamless steel tubing, threaded at the ends. If additional bearing is needed between pin and steel bars, a disc of steel would be welded to the latter. Mr. Gruber said that for a typical fitting 22 rivets on the metal mast would carry the same bearing stress as 165 wood screws in spruce.

Other more complicated fittings are even more readily attached. The track for the main boom, when made (as illustrated in the right hand cut on page 80) of a monel metal casting, with strap for attachment to a wooden mast, weighs approximately 100 lb. This track allows the forward end of the boom to be hauled down to tighten the main sail. When made of stainless steel and riveted into the duralumin mast (as are the spinnaker boom tracks shown on the front of the mast — page 79) it weighs hardly one quarter as much. Many fittings on all the contending yachts, such as sail slides and boom ends, are of monel.

Notable savings in weight have been made in the standing rigging and its fittings. Usual construction is to use plow steel stranded wire rope for both the flexible halyards (which run over blocks) and the stays, which end in links or turnbuckles. At all places where flexibility is not essential, Mr. Burgess has installed single strand, 19-wire steel cable. As an instance, a 1 x 19 cable, $\frac{7}{8}$ in. diameter has a 92,000-lb. breaking load; a 6 x 7 plow steel rope, $\frac{7}{8}$ in. diameter, has a greater elastic stretch and a 66,000-lb. breaking load. Put in others words, a 1 x 19 cable, $\frac{7}{8}$ in. diameter, may replace a $1\frac{1}{8}$-in. stranded rope, thus saving weight and windage of rigging.

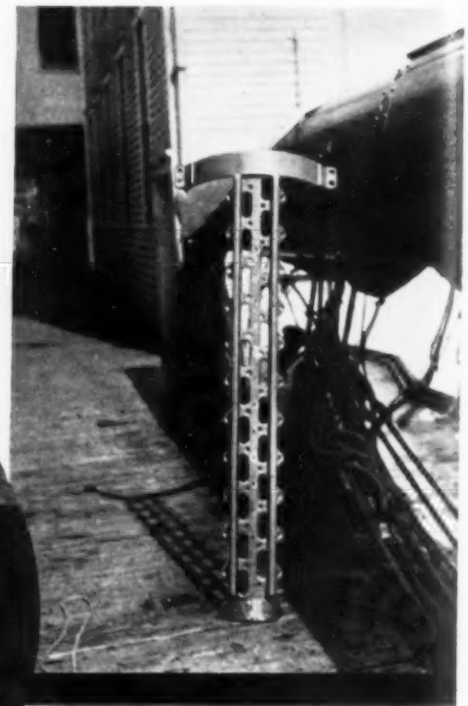


One difficulty formerly experienced with stiff single strand cables has been surmounted by the American Cable Co. in developing its "tru-loc" shroud ends. These are shown in the detailed view of the wooden mast, page 80, and even more clearly in the deck view, at left. They consist of a short length of seamless tubing, slipped over the cable and compressed against the wires by cold rolling. The length is chosen so that the cable will break before the tubing will slip off. The tubing is then threaded for attachment to a hook, eye or turnbuckle. Such a fitting saves some weight of the old "spliced-

eyes" used at the ends of flexible strand, and eliminates trouble in splicing the stiff 1x19 cable.

Hooks, eyes and turnbuckles were made by Glenn L. Martin Co., of S.A.E. 4140 steel, heat treated to 125,000 lb. per sq. in. tensile strength. Blocks have duralumin shells and

Cable Is Socketed Into Seamless Tubing and Threaded Into Heat Treated Alloy Steel Turnbuckles, Eyes or Hooks



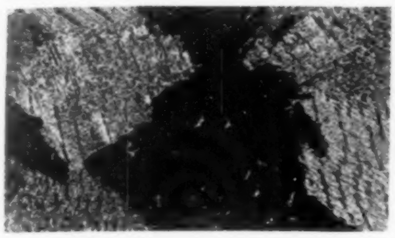
Monel Metal Fittings Used on Wooden Masts to Subdivide Stresses to Many Screws

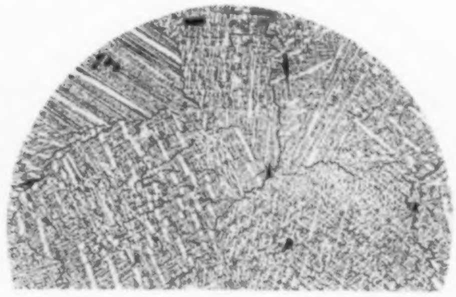
sheaves; the strap and shackle are of steel, and the steel pin is bronze bushed. These are made by Merriman Brothers, Boston, and are similar to those still used on the Resolute and Vanitie and supplied when they were built in 1914.

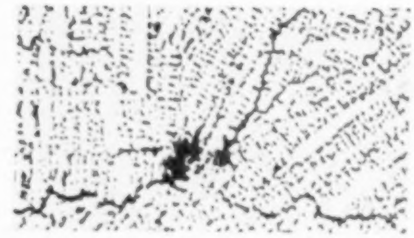
Another interesting detail, where about half of the weight has been saved, is seen in the spreaders — the four short struts at the sides of the mast. (A land-lubberly engineer would say that the mast is a trussed beam, and the spreaders are the queen-posts. They are prominently shown in the birds' eye view on page 76.) Wooden masts first fitted to the Enterprise had hollow wooden spreaders, stream-lined in cross section, about 15 in. by 6 in. in outside dimension and 14 ft. long, with cast lynite end fittings. Each weighs about 140 lb. These have been replaced by tubular steel members of equal strength weighing about 70 lb. The latter are round in cross section, about 5 in. diameter in the center, tapering to 3 in. at each end. Each one is made of eight pieces of thin chrome-molybdenum sheet, properly bent, welded together and to similar alloy end fittings, and the whole piece heat treated after fabrication.

Remaining space is sufficient merely to mention the many other metal parts going into the construction of the cup defender. The illustrations show some of them. Cleats are of bronze, as are the small winches below decks. Grab rails about the decks are of aluminum (3 SH). Center boards are a slab of bronze, 1⅜ in. thick, one cast, the other rolled. The track for the mainsail, riveted to the mast, is a strip of duralumin, (17 ST) 1½ by ¼ in., 145 ft. long in one piece. Sail-slides are of monel metal or stainless steel. Many fittings between decks are of strong aluminum alloys. The lead keel is attached to the hull with bronze bolts. Some Allegheny metal is used for hanger fittings; some are steel forgings. In all, it is fair to say that the Enterprise is a metal ship!

Structure of Aluminum-Copper Alloys







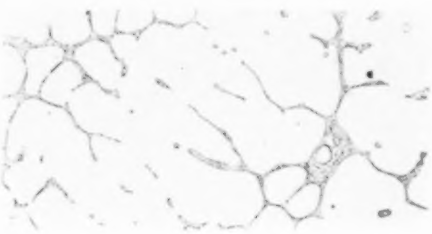
Dendritic Structure in 8-per cent Copper Alloy of High Purity

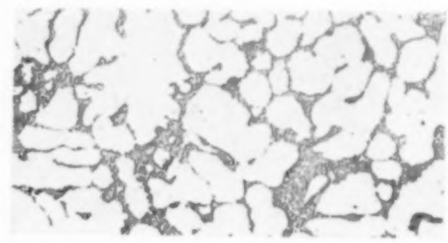
(Sand-cast test bar, ½-in. diameter)

Etched deeply with solution of 10 per cent HF plus 10 per cent HNO_3. Unusually coarse grained, partly on account of its high purity. Magnification 5 X.

Unetched; magnified 7 diameters. Dendritic nature of grains is quite evident. Grain size in ordinary castings is usually smaller and less perfectly developed.

Unetched. Junction of three dendrites. Magnified 30 X. A small shrinkage cavity occurs at the junction. Inter-dendritic network of $CuAl_2$ is also apparent.





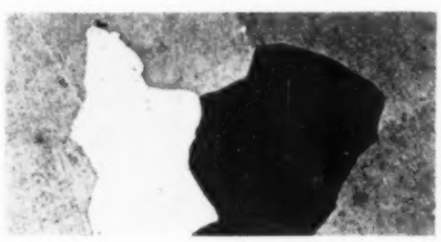
Microstructure of High Purity Alloys with 5, 8, and 12-per cent Copper

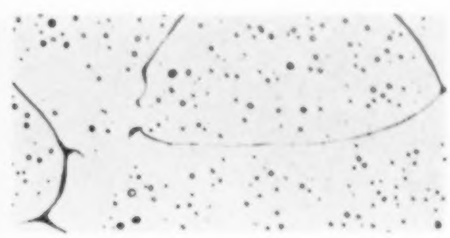
(Sand-cast test bars, ½-in. diameter, unetched, magnified 75 times)

5-per cent Copper Alloy. Shows partial network of the eutectic (aluminum-$CuAl_2$) around dendrites and between dendritic branches.

8-per cent Copper Alloy. Junction of two dendrites. $CuAl_2$ shows considerable coalescence. The distinct network between dendritic grains shown here, and in the two photographs on the right, above, is unusual in aluminum-copper alloys of commercial purity, but may be found in large ingots of alloys containing about 4 per cent Cu.

12-per cent Copper Alloy. These three alloys contain less than 0.05 per cent impurities, and the increasing amount of $CuAl_2$ is evident.





Effect of Solution Heat Treatment and of Burning

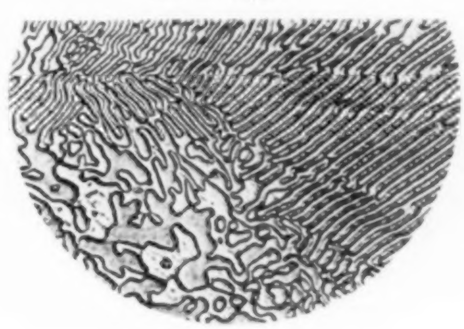
(5-per cent copper alloy, impurities less than 0.05 per cent, magnified 75 times)

Sand cast test bar, heated 48 hr. at 544 deg. C., quenched in water. Etched in aqueous solution containing 0.5 per cent HF. In other fields the network is entirely absent.

Same as at left, but etched with aqueous solution containing 2.5 per cent HCl, 1.5 per cent HNO_3 and 1 per cent HF. Shows grain contrast and uniform distribution of copper.

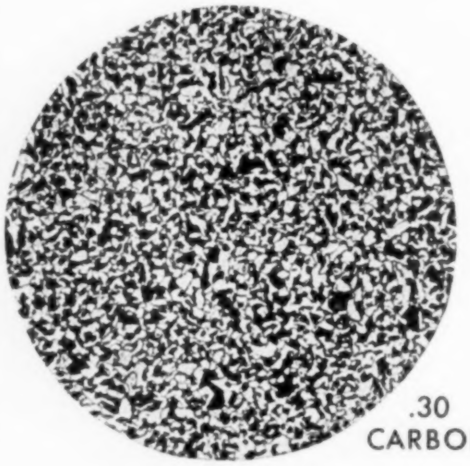
Overheated or burned alloy. Forged alloy of high purity, heated 9 days at 540 deg. C., quenched, reheated to above solidus and quenched. Rosettes appeared before grain-boundary fusion. Unetched.

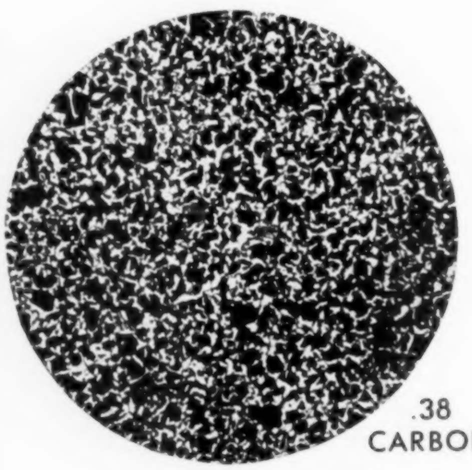
Photomicrographs by Aluminum Research Laboratories, Cleveland, Ohio.

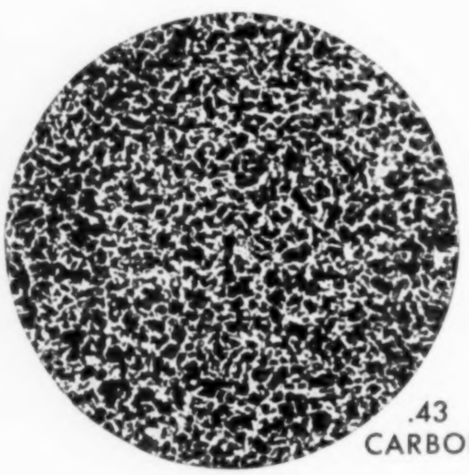


Aluminum-copper Eutectic 33.3 per cent Copper

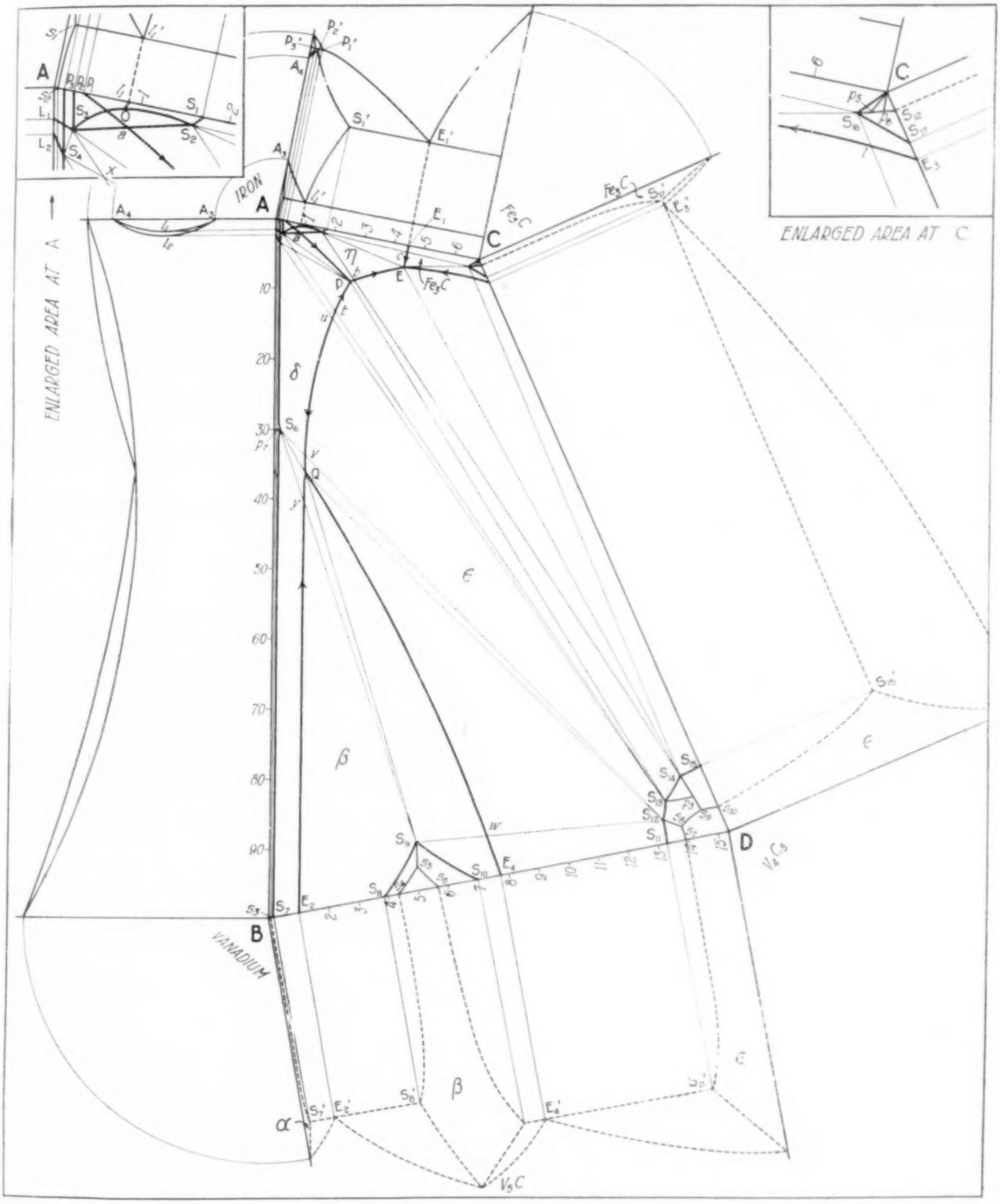
At left. Cast in green sand as ½-in. diameter test bar. Etched in aqueous solution containing 10 per cent HNO_3 and about 1 per cent HF. Hard constituent is $CuAl_2$ in matrix of aluminum containing a small amount of copper in solid solution. Magnification 750 X.







Iron-Carbon-Vanadium Equilibrium Diagram



According to Masakichi Oya

This diagram is the result of studies from 1926 to 1930 at Imperial Japanese University, and corresponds to the facts reported in a series of five papers in *Science Reports* of that University.

It was forwarded by Dr. Honda in his current letter from Japan printed on page 114 of this issue of METAL PROGRESS.

Cooperative Research

Essential for Small Enterprises

IT has been long recognized by leaders of industry that much is to be gained by cooperation in certain lines of work. To eliminate competition may be to court disaster; but, where competition can effect no good, it is recognized more and more clearly that cooperation is not merely desirable but almost imperative. Especially is this true when investigating and standardizing materials employed in the manufacture of engineering equipment. This accounts for the successful efforts already made by engineers to standardize tests on materials which they intend to use in the construction of various devices, and to specify the properties required in these materials.

Sooner or later, two questions present themselves to those interested in the problem of standardization: "Are the present standards good for all time?" (which is most unlikely) and, "Are the materials specified for a particular service the best that can be obtained for that service?" In order to answer these questions, particularly the latter, individual firms of courage and enterprise have organized research departments for the purpose, among other things, to investigate new materials and processes and develop new fields in both pure and applied science. Without question, these firms have benefited by the scientific investigation of new ideas. It is utterly impossible, even for these firms, to estimate the returns made for the money expended; such values cannot be measured, as they have to do not merely with the financial but with the moral effects produced within these organizations through the improved methods successfully applied in practice.

It is natural that the larger organizations should have been the first to enter this field, and equally so that many smaller concerns should have envied the results obtained through the organized efforts of skilled scientists and trained minds. Some of the more forward-looking of the smaller manufacturers have proposed to their competitors the possibility of cooperation with the view of eliminating such waste as results from needless duplication of effort. Many examples of cooperative effort along these lines could be cited.

By O. W. Ellis

Every firm eventually lives or dies, according as it does, or does not, produce goods deemed worth the money paid for them by the user. Hence, the efforts made by many firms, not merely to investigate new materials

and processes, but to apply scientific thought to the problems of production. So far, no one has, I believe, ventured to suggest that cooperation along these lines is of vital importance. This still remains a field wherein competition is felt to be of real value.

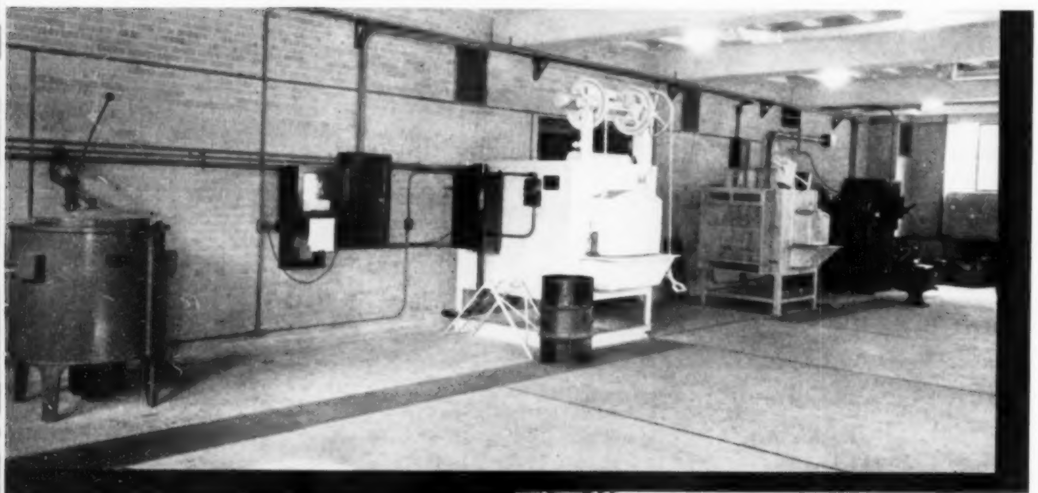
However, competitive research into the fundamental characteristics of materials is recognized as undesirable even by the largest organizations. And certainly the smaller firms can but choose to unite for the purpose of conducting such investigations as are likely to improve their product or to eliminate waste and unnecessary effort.

For many years, groups of manufacturers in Great Britain have received governmental support in their cooperative research. The British Non-Ferrous Metals Research Association and the British Cast Iron Research Association are outstanding examples of the type of organization referred to in the above paragraphs.

We do not need to go across the ocean for examples. Some two years ago, the Province of Ontario, Canada, inaugurated the Ontario Research Foundation, Premier Howard Ferguson having obtained the consent of the provincial legislature to carry out research work having the following purposes:

(a) The improvement and development of industry by the introduction of advanced methods and processes;

(b) The discovery and better development



Ontario Research Foundation is Already Housed in a Beautiful Building, Two Stories in Height. It is so arranged that it eventually may be doubled in height, thus providing four floors each with approximately 180 by 75 ft. available for laboratory space. The other views show some of the equipment provided for metallurgical research. In one room are homo, annealing, globar, and high frequency furnaces. Machine shop contains lathe, shaper, milling machine, drill press, universal grinder and auxiliary small tools. Mechanical testing laboratory has 50,000-lb. universal machine, fatigue testing equipment, impact machine and various hardness testers. A long room, two stories high, commanded by a crane, houses large equipment.

of the natural resources of the Province and the utilization of the by-products of any process dealing with the mineral or timber resources;

(c) The improvement of agricultural industry and farm life;

(d) Scientific investigation of disease or parasites in animal or vegetable life.

The Government promised to match dollar with dollar, up to a certain limiting amount, with such industrial organizations within the Province and such public-spirited individuals as desired to contribute to these objects. A total reserve of over $3,800,000 is set aside.

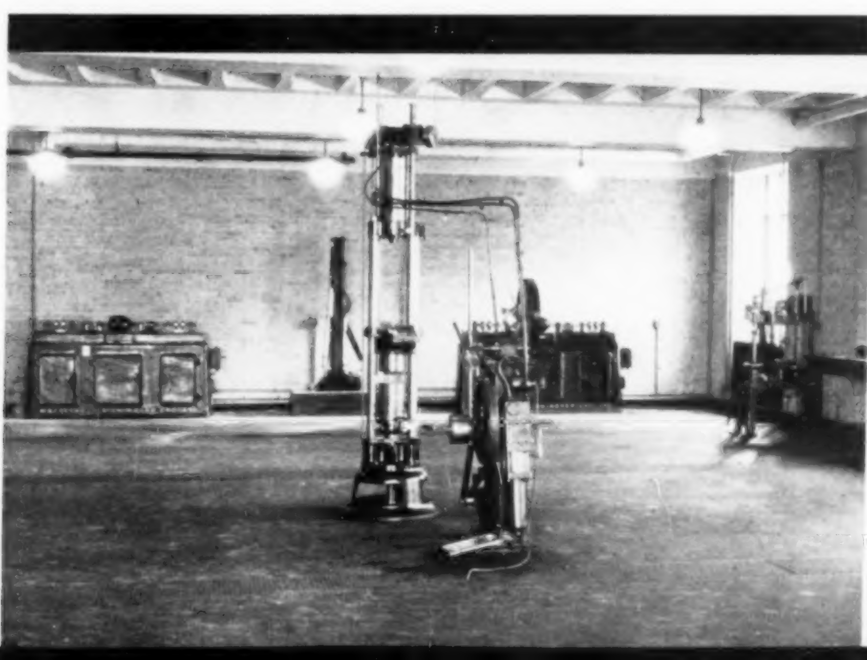
In the fall of 1928, the Ontario Chapter of the American Society for Steel Treating appointed a committee to confer with Director Speakman concerning the formation of a metallurgical division. These deliberations resulted, on the one hand, in the appointment of the writer as director of metallurgical research at the Foundation and, on the other hand, the organization of what is now known as the Ontario Metal Industries Research Association.

This organization has now about 60 members. Each subscribed to the association according to a scale decided by an appropriate committee. At the moment, the problems of individual members within the association are brought to the attention of an Advisory Research Committee, which decides the problems meriting prior attention and likely to be of most value to the membership as a whole. Some of the questions brought to the metallurgical division may be answered so readily as to necessitate no reference to the Advisory Research Committee, and in this respect a certain amount of discretion is left to the director.

So much for what might be termed the everyday problems which arise during the manufacture of metals. There are, as well, problems of wider interest, such as the investigation of alloy systems to determine the characteristics of the system as a whole, and the particular characteristics of individual alloys in the system. Work of this nature is already being carried out by the metallurgical division. The information obtained will be available to all members of the association, and it is likely that the results will be made public.

Here, then, we have a brief story of the organization of a scheme of cooperative research which is being carried out successfully in the Dominion of Canada. One point may be referred to in closing. It is becoming increasingly clear that the membership of the Ontario Metal Industries Research Association must of necessity be grouped in accordance with those particular metallurgical investigations in which they are primarily interested. Such natural groups as readily come to mind are: a cast iron group, a group interested in alloys for use at high temperatures, a steel treating group. While the information obtained through investigations carried out for each of these groups would be primarily of interest to members of each group, it will naturally be available to members of the Association as a whole. So far the situation has not required such grouping.

The method of approach described above has in the main proved quite satisfactory. What is adaptable to Ontario might not, of course, be desirable for other parts of the world. Particularly is this likely to be the case where bodies larger than those described above are created. The smaller the parent association, the fewer the members vitally interested in any particular type of problem. The converse is true of the larger groups, hence the likelihood of its being necessary to divide them, when they exist, into smaller ones.



Fitting a Small Diamond into the Shank of a Platinum and Star Ruby Ring. The diamond is first set tightly in a depression which has been carved in the platinum. So that the stone will not fall out, the jeweler is forming beads of metal to act like claws and hold the diamond in place. The tool he is using, a "bull sticker", has a cup on the end to mold into beads the metal he pushes up. Larger stones are often fitted into bezels, collars or cups of whatever metal is used for the particular piece of jewelry. The bezels are then soldered into place. When gems are secured by prongs they are said to be in a Tiffany setting.

Alloying for Beauty

IN PREHISTORIC AGES men fashioned articles, some useful, others merely shapely, from chunks of soft yellow metal. The metal was gold; the men, the first metal workers.

Gold happened to be the first metal which man worked because it was found in nuggets in stream beds — the earliest roads — and was soft enough to yield even to the insistence of the stone hammers and edged tools of bone then available. Though too soft and too rare for utilitarian use, gold has never lost its position as the king of beautiful metals.

The modern worker in gold is an artist, a craftsman and a metallurgist. He realizes the inherent beauty of the metal, has skill to interpret its beauty with his hands and knows the secrets of hardening and coloring it to preserve his work in original perfection.

In Cleveland at the Potter-Bentley Studios, men design and execute gold into beautiful jewelry. In making fine rings, pins, necklaces or bracelets, they have found it advisable to forget the economies of mass production in favor of individuality and artistry. Modern equipment has its place — electric drills and scientifically designed melting furnaces have proved dependable and efficient — but the men at the studios guide the drills through a single piece of gold, silver or platinum, and melt only a few ounces of metal in a heat.

The metals of industry — iron, steel, aluminum, zinc, lead and all the rest — are, of course, variously alloyed. But the purpose of an iron-tungsten-carbon alloy is not added beauty but increased usefulness, and whether a duralumin girder looks more attractive than an aluminum one is not a weighty question with the designer of rigid airships. On the other hand, those who love and buy fine jewelry do not worry about gold's tensile strength or Brinell hardness, but they are much concerned about its appearance.

Women influence the selection of fine jewelry even more, perhaps, than they do the selection of automobiles, pianos and radios. When a man buys jewelry, it is seldom for himself, almost always for a lady, and if he is wise he will not disregard colors in choosing between two equally beautiful designs for a dinner ring.

His field of color selection is wide, for there are gems of almost every shade, and the jeweler is prepared to melt for him a precious metal of whatever color is needed to show off the stone to best advantage, and still harmonize or contrast perfectly with the complexion of the lady who will wear it.

Since color is so important in jewelry metal, men who make fine jewelry must know something about metallurgy. What would be the use of a man buying the most beautiful brooch in all the world if its color did not suit the wearer?

The Potter-Bentley craftsmen melt the four distinctly colored alloys of gold usually en-

Forming a Bracelet with a Rawhide Mallet. The mallet does not scar or scratch but is hard enough to curve the bracelet into proper shape

No Tonnage from this Foundry. Slightly over four ounces of gold are being cast into an ingot. The gas-fired melting furnace is shown at the right

countered, namely, red, yellow, green and white. They also can vary the composition slightly to get just the right shade in between to suit some customer. Golds from 8 to 18 carats in purity are most generally used, a carat of gold being $\frac{1}{24}$th part of the weight of the alloy. Pure 24-carat gold is too soft for jewelry, so the alloying metals, copper and silver, serve the double purpose of hardening and coloring.

Yellow gold approaches most nearly the color of the pure metal. Brunets like the effect of the contrast between their dark hair and the sunny brilliance of the gold itself. Most brunets do not know, however, that the 14-carat yellow gold in their jewelry has 6 parts of copper and 4 of silver mixed with 14 parts of fine gold.

Warmer and richer in color than the yellow is red gold, chosen by many of the fair haired and light complexioned. This gold contains no silver, just pure copper and fine gold. Its delicate ruddiness pleases the connoisseur of colors, jewelers say. A 14-carat red gold has the stated 14 parts of pure gold and 10 parts copper.

Thousands of brown-eyed women whose hair is medium or dark brown prefer a greenish tone. The whiteness of platinum or white gold does not become them, they have told their

jewelers, as much as the softer but more definite shades of green golds. So there is a steady demand for beautiful ornaments made of 14 parts fine gold, 8 parts fine silver and 2 parts copper. White diamonds loose no sparkle in such settings; topazes, aquamarines and other jewels in pastel shades take on added attractiveness.

For some time, though, white metals, carved and chased, have been the favorites. They probably gained popularity as a reaction to the little-relieved simplicity of yellow and red gold jewelry, the favorite of the older generation. Diamonds set in platinum or white gold show to great advantage, as do rubies, sapphires, emeralds and other gems of vivid color.

Platinum, alloyed with either 5 or 10 per cent of iridium, is the most expensive and the most generally demanded of all jewelry metals in use today. Iridium must be added to harden pure platinum, even though it is the more expensive of the two. For some reason not even known to jewelers, platinum to which 5 per cent iridium is added is called a 5-per cent platinum alloy; 10 per cent iridium makes a 10-per cent platinum alloy. Both the 5- and 10-per cent alloys are difficult to cut with edged tools. The tool digs in, and instead of a long smooth chip curling back over the tool, little slivers are torn out, leaving a rather rough cut which must then be smoothed.

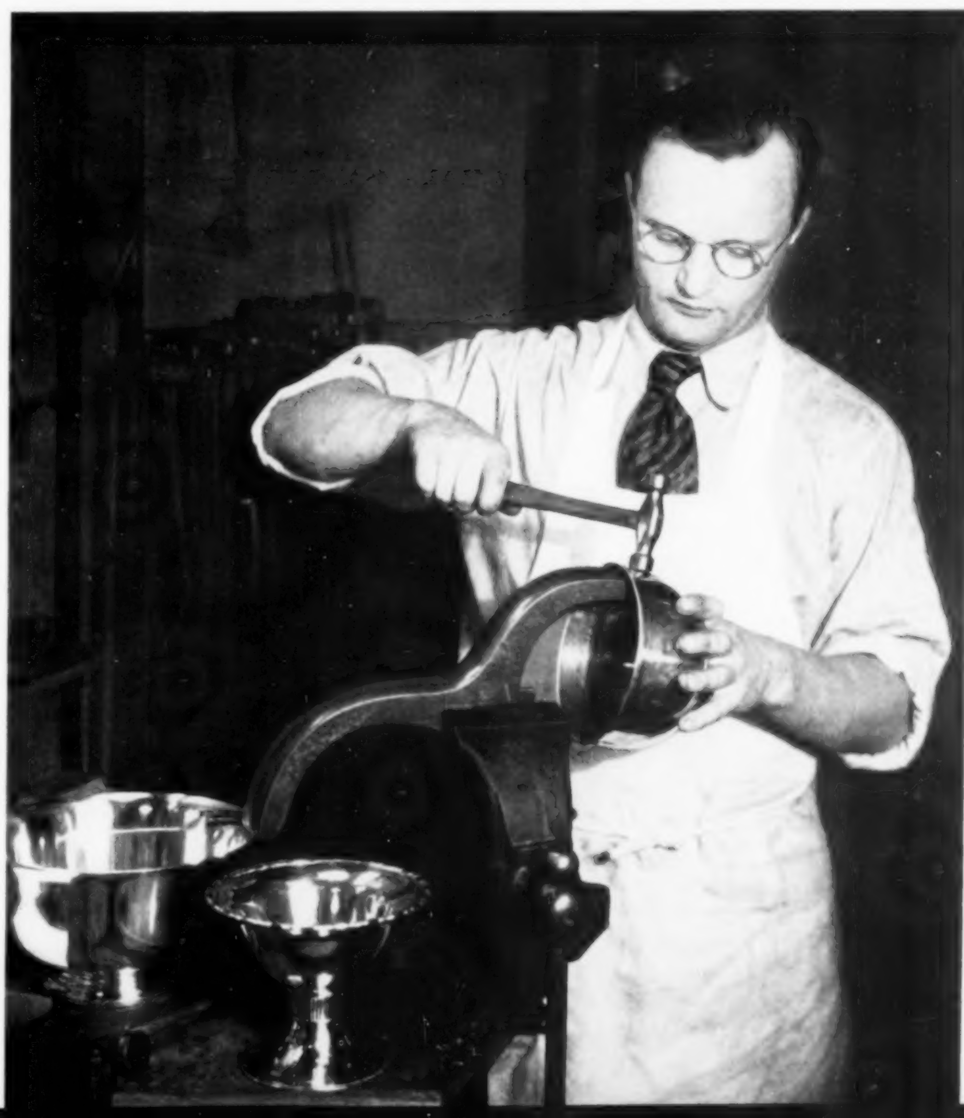
White gold is frequently used instead of platinum because of its lower cost. Until very recently, the formula and manufacture of white gold was looked upon very much as a secret. Jewelers did not, nor do they now as a rule, melt their own white gold. The process is complicated and adequate service can be secured from big manufacturing jewelers.

It is an alloy of nickel and fine gold, the nickel content running as high as 19 per cent and as low as 14 per cent. It is very tough and hard to work with hand tools. It can be stamped rapidly and easily, however, which accounts for the number of white gold rings exhibited at ridiculously low prices in pawn-shop and third rate jewelers' windows.

Sterling silver has lost much of its pristine prominence as a metal for personal jewelry, but is still in demand for flat ware, bowls, ornaments and the like. The word "Sterling" on a piece of silverware certifies that the silver is 99.25 per cent pure and that a maximum of 0.75 per cent copper has been added to make the metal hard enough for service.

Potter-Bentley Studios melt their own alloys,

Silver Bowls are First Spun, then Finished with Hammers. When the planishing hammer, shown here, has done its work the bowl will be ready for final smoothing and polishing



Many Rings Have a Hundred Pieces. Separate parts of the ring are soldered in place with this torch. Care must be taken that previously soldered pieces are not melted

except white gold, in gas fired furnaces just large enough to hold one little four-ounce crucible. The ingot molds are shaped to produce a flat slug which can be conveniently cold rolled into sheet or strip from which almost every kind of fine jewelry is built. Melting is a rather simple operation since the various metals are bought in the pure state and need no refining. Gold and silver are melted under a powdered borax flux to prevent oxidation, but the flux is not necessary when platinum is melted. The latter, of course, requires a very high heat.

Fabrication of attractive pieces of jewelry may not be measured in hundreds of pieces per day, but it is by no means slow. When a man decides to give his sweetheart an engagement ring, he calls at the studio and describes the ring he has in mind. If he cannot find his ideal in the display of rings made at various times for over-the-counter sale, designs are drawn according to his specifications. The design finally chosen may be, for instance, a green gold ring into which are set two fairly large white diamonds with four much smaller brown diamonds as part of the decoration.

The proper alloy of 8 parts silver, 2 parts copper and 14 parts fine gold is then melted, cast and rolled into a sheet of green gold about $\frac{1}{16}$-in. thick. A ring blank is cut from the sheet as the first step in forming the band and shanks. The band runs around the under side of the finger and the shanks are the sides of the ring.

The number of gems in this ring and the intricacies of the setting may mean that the finished ring will be built up from nearly a hundred separate pieces. Metal for the table or top side of the ring is next cut from the original sheet. The table will hold the two white diamonds and two of the coffee-colored ones. Each stone must be fitted into a metal collar or bezel, which is then soldered into the hole which has been cut for it on the table. A modern leaf and flower motif completes the table. Most of the details are carved and shaped from the original sheet, but the low relief work is cut into the table itself with line gravers and scorpers, both of which are hand tools used for general carving and engraving. When a brown diamond is set into each shank and the carving and building up of the shank design is finished, the ring is complete.

Despite the necessary number of manual operations, this ring can be worn in less than ten working hours after the design is approved and the diamonds secured.

Investment in automatic or semi-automatic machinery would return little profit to a shop with an ideal of having each piece of jewelry different from the ones which have been made before. People are not alike, and jewelry should be personal to the man or woman who wears it.

Continuous Nitriding

A New Development

CASE HARDENING steel by nitriding has been developed as an intermittent or batch type process. Separate lots of metal in a special container are treated with ammonia gas for the required time; the whole cycle is completed before another lot is started. Commercial developments have followed along the same line and the furnaces being used apply different modifications of the batch type process.

At the Cleveland meeting of the American Society for Steel Treating in 1929 attention was called to this fact and the desire was expressed that a continuous process might be developed. Since it was thought that this would be a distinct contribution to progress, the matter was studied in the laboratories of Surface Combustion Co., Inc., Toledo, Ohio, and some very unusual results have been obtained.

As a result of this work, there has been developed a process for continuous nitriding which has many interesting features and which will be described below. Suitable equipment has also been devised to carry out this process, and it is now offered as a contribution of the furnace manufacturer to the nitriding art.

As the art is practiced at present, two different types of heat cycles are being used for intermittent nitriding. Either a low temperature cycle of about 900 deg. Fahr. or a high temperature cycle of about 1150 deg. Fahr. is used, separately or in different combinations. Sometimes, the low temperature treatment is given first, followed by one at high temperature; and at other times, the high temperature is used first and then a low temperature. Generally speaking, nitriding at low temperature produces maximum hardness, while high temperature produces maximum penetration.

By
R. J. Cowan

The low-to-high cycle seems to be designed to produce first of all a case of maximum hardness which is caused to diffuse and penetrate by a subsequent heating at high temperature. The high-to-low cycle aims to produce maximum penetration at first, with subsequent diffusion.

Those metallurgists who use these different cycles have definite reasons for their choice and the writer has no thought of entering into a discussion as to the relative merits of either method. As a matter of fact, the new continuous process for nitriding may be used with any heating cycle desired.

To carry out this continuous process the Surface Combustion Co., Inc., has developed two furnaces, one of which is shown in general outline in the sketch. This consists of a metal muffle, continuous throughout the furnace. The latter is fired from both sides by gas burners arranged so as to be under accurate pyrometric control. By this means definite temperature zones can be maintained as desired. The ends of the muffle are encased in a metal hood and the work to be nitrided is brought into the

muffle on a tray through a liquid seal. A pusher arm operating on the inside of the seal moves the work progressively through the furnace. A similar arrangement at the discharge end removes the completed work. The trays are carried above the floor of the muffle so that ammonia may be admitted both above and below the trays and forced through the muffle in the same direction as the work. A suitable discharge and seal is arranged for exhaust gases.

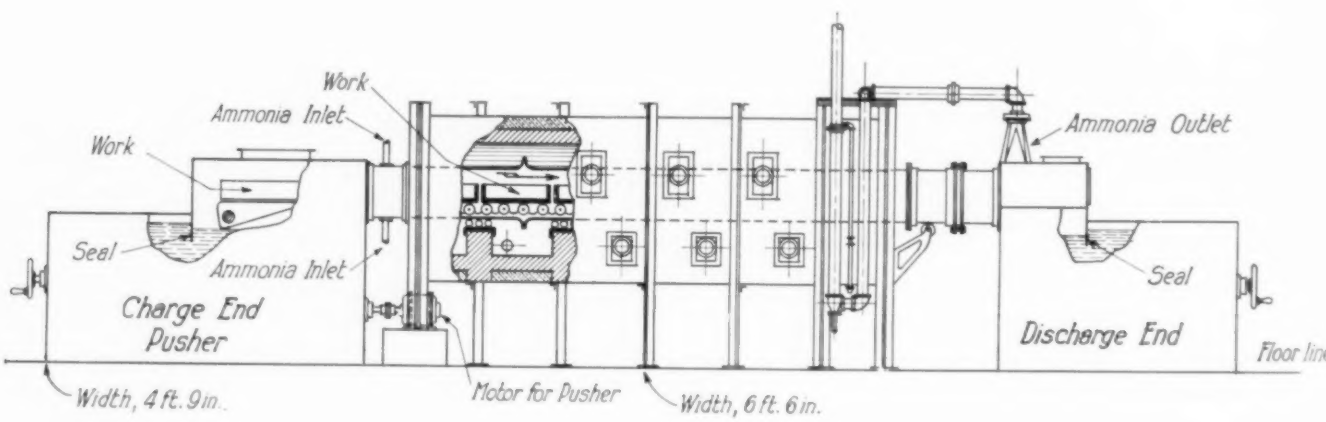
A second furnace, not shown in detail, contains an alloy pan conveyor arranged to operate continuously through suitable seals. The alloy used is of a correct analysis to operate under these conditions.

The outstanding merit of this process is that the nitriding operation itself is continuous, for the metal surfaces under treatment are being continuously exposed to ammonia of the degree of dissociation suited to the temperature of the work. Ammonia samples taken at different points along the muffle have indicated a progressive dissociation towards the outlet end. It is apparent that this is a matter of greatest importance, and it will be considered later in more detail.

The operation of the batch type and of the continuous process is fundamentally different because the requirements of the outlet gases are so different.

In the intermittent process, it is necessary to draw off ammonia at such a rate that only about 35 per cent of it is dissociated in order to obtain proper nitriding. The reason for this is that hydrogen as well as nitrogen is liberated when ammonia breaks up, and if more hydrogen than that represented by 35 per cent dissociation is present in the gaseous mixture, it has a decarburizing action on the metal being treated. Decarburization prevents the best nitriding results.

In order to get the best and hardest cases by this type of process, the gases must be thoroughly agitated in order to sweep away from reacting surfaces any high concentration of hydrogen. The reason for agitation is not so much to bring ammonia into contact with the work as it is to keep hydrogen away from new metal surfaces.



A Furnace for Continuous Nitriding Consists Essentially of a Long Muffle, Placed in an Appropriate Furnace Setting, and Through Which the Work Can Be Pushed or Carried at a Controlled Rate. Air locks or seals are necessary at both entrance and exit in order that the ammonia gas may be imprisoned. If the furnace is of correct length and the burners properly set, the advancing metal under treatment automatically passes through the correct cycle of temperature and nitrogen concentration to acquire a hardened surface of desired characteristics in the minimum time and at lowest cost.

It is therefore necessary to effect a compromise between hydrogen concentration and ammonia dissociation which will work satisfactorily. Unfortunately this compromise means a loss of 60 to 70 per cent of the nitriding medium, and this adds appreciably to the cost of the operation. Unfortunately, also, this means that full strength ammonia is never in contact with the new metal surfaces.

In the continuous process, ammonia enters the reaction chamber along with the work and travels in the same direction as the work during the entire operation. By this means, the new metal surfaces can come into contact only with full strength ammonia which exerts its full nitriding power on the metal at a time when it

is most susceptible to its action, and without any retardation from excessive hydrogen decarburization. For this reason it is not necessary to agitate the gas to prevent decarburization.

Economical Use of Ammonia

The flow through the muffle can be regulated so that the ammonia escaping at the outlet will be broken down to any desired degree. The process furnishes an automatic protection from the action of excessive hydrogen, as will be shown in more detail later, and therefore as much as 85 to 90 per cent of the ammonia can be dissociated before reaching the end of the muffle and still produce excellent nitriding. This is due to the fact that the free hydrogen resulting from the chemical reactions cannot come into contact with new metal surfaces in high concentrations, since the gas is flowing through the furnace in the same direction that the work is moving.

Experiment has shown that hydrogen has little action on a *nitrided* surface. It is objectionable only when it reacts with new metal surfaces by decarburizing them. It will be seen, therefore, that by the continuous method of nitriding it will be possible to bring full strength ammonia directly to the metal surface being treated, and to use all the ammonia admitted to the system without danger of decarburization.

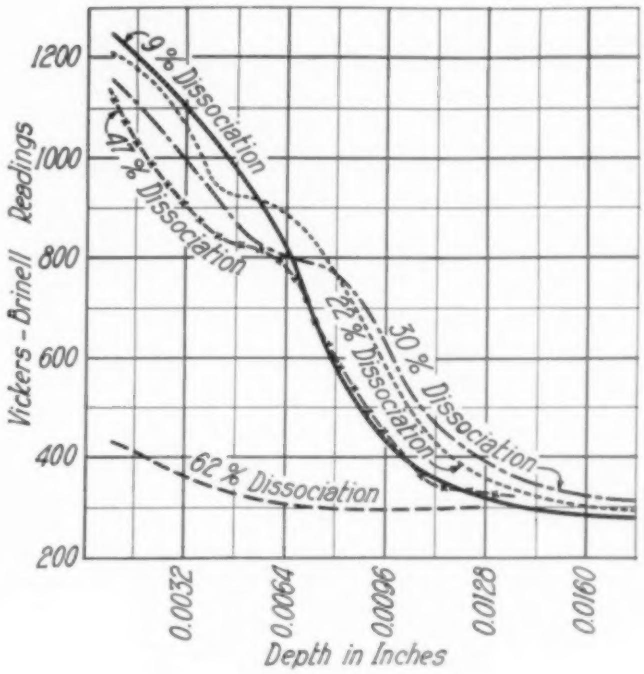


Figure 1
Undissociated Ammonia Gives the Hardest Nitrided Case

A description of tests leading up to the development of this process will now be given, largely as captions to curve sheets.

The first chart shows the hardness-penetration curves of a nitriding steel after exposure to ammonia maintained at a constant degree of dissociation through each test. These tests were run in a five-tube laboratory furnace in which the outlet gas from one tube was introduced into the next. By this means it was possible to secure different degrees of dissociation in each tube, varying from 9 per cent in the first tube to 62 per cent in the last. Time at 900 deg. Fahr. was 48 hr. Results confirm the propriety of the usual practice of drawing off the ammonia in a low state of dissociation. It is evident that when bare steel is exposed to ammonia dissociated much over 50 per cent, the results are not satisfactory.

Results obtained by nitriding under conditions of variable dissociation are shown in the sec-

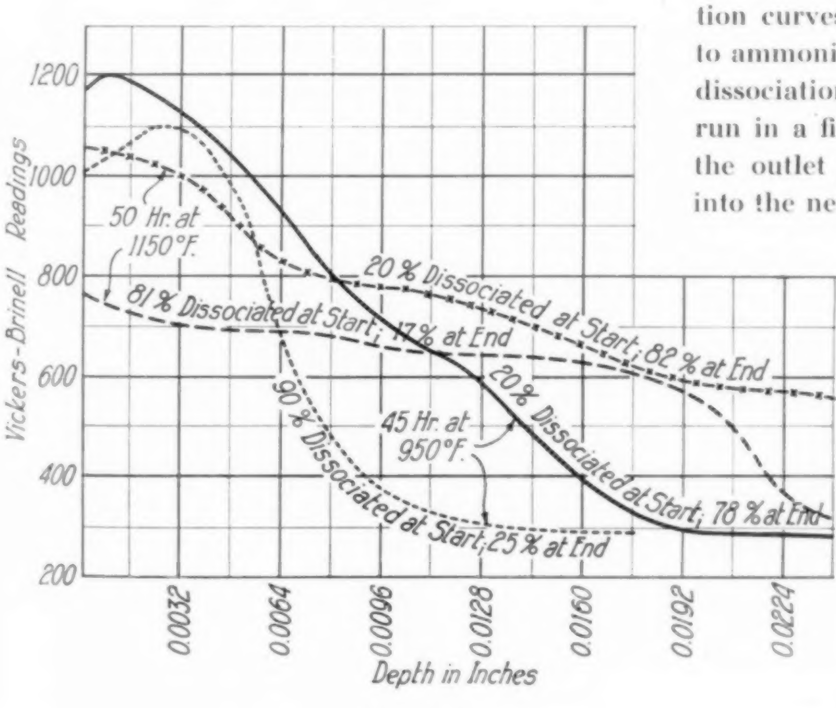


Figure 2
Best Surface Hardness Is Produced By Starting With Relatively Pure Ammonia at a Low Temperature, and Increasing Both Dissociation and Heat as the Action Progresses.

ond chart. In these experiments the dissociation was changed continuously throughout the run, in one case varying from high to low and in the other from low to high. Two temperatures were used, namely, 1150 and 950 deg. Fahr. It is a significant fact that each time the dissociation started at a low percentage and increased, the results were much better than when the opposite conditions prevailed. This chart is of particular importance to show the direction of gas flow best suited for continuous nitriding. If the ammonia is introduced into the muffle so as to run parallel with the incoming work, the ammonia dissociation as it comes in contact with the work will vary from low to high. That is to say, the surfaces to be nitrided will be first acted upon by the most powerful nitriding gas and later by the more highly dissociated gas.

It is well to point out that highly dissociated ammonia is made up of considerable hydrogen whose decarburizing power is notorious. Many investigators have called attention to an unsatisfactory nitrided surface resulting from excessive decarburization. Our results confirm their findings in pointing out the danger of inferior work when highly dissociated gases react with new metal surfaces.

Rich Ammonia At Start

Evidence is very convincing that the ammonia must move in the same direction through the muffle as the advancing work, that is, the dissociation must vary from low to high. This will bring the rich nitriding gas into direct contact with new metal and avoid any danger from decarburization. For this reason we have adopted in our continuous process, as an essential idea, the practice of causing the ammonia gas to flow parallel with the work. Later charts indicate that if, in the work recorded on this chart, we had started with dissociations of still lower values, the cases would have been still better.

Mention has been made of the fact that the subsequent action of free hydrogen on a properly nitrided surface is not objectionable. This is shown in detail in Fig. 3. In this test a specimen that had been nitrided was exposed to the action of hydrogen at a temperature of 1150 deg. Fahr. for 36 hr. The piece was slightly softened, as shown by the curves, but the effect is no greater than if the piece had been heated for the same length of time in a neutral atmosphere. This points to the fact that a surface which has been nitrided is protected from subsequent softening by the hydrogen in a highly dissociated ammonia gas. It also indicates the fundamental difficulty with the batch type proc-

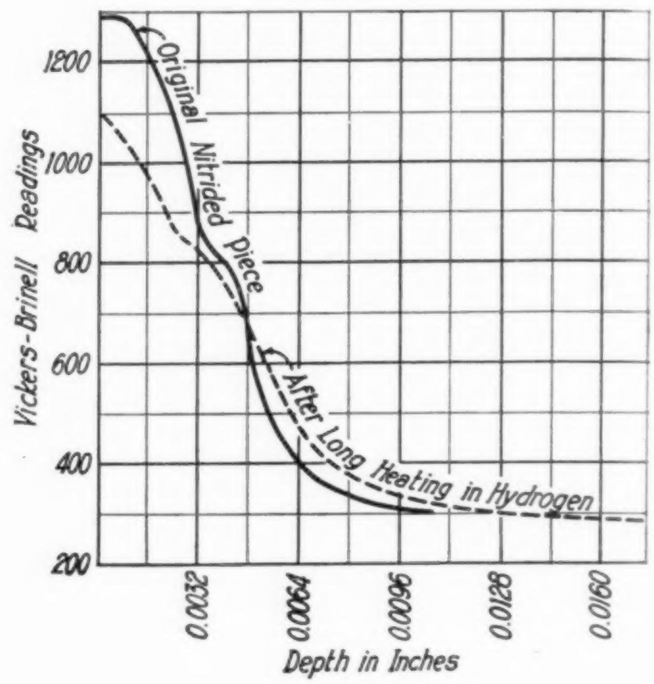


Figure 3
Long Heating in Hydrogen Does Not Soften a Properly Nitrided Surface

ess, since it is impossible to avoid the action of hydrogen on new surfaces. Agitation of the gases is only a palliative.

Figure 4 presents the results of some work with different heat cycles. We adopted two temperatures, 1150 deg. Fahr. and 950 deg. Fahr. for this study, 4 hr. at each heat. The two lower curves show what is possible by the batch type process where a constant ammonia dissociation of 30 per cent is maintained with different heating cycles. When the higher temperature reactions are given first, the steel has a lower surface hardness. These two curves are included for comparative purposes, and indicate what we were able to do by the batch type process with constant dissociation and short heating cycles.

The same chart presents the results obtained

from the first attempt to nitride continuously in a commercial manner. This work was done in our laboratory in a small sized unit, for a customer who needed some results in a hurry. The ammonia dissociation at the outlet of the muffle was 90 per cent and the total time 16 hr. The single curve is an average of a number of tests, all about alike. A duplex cycle was used for this work which consisted of 8 hr. at 950 deg. Fahr. and 8 hr. at 1150.

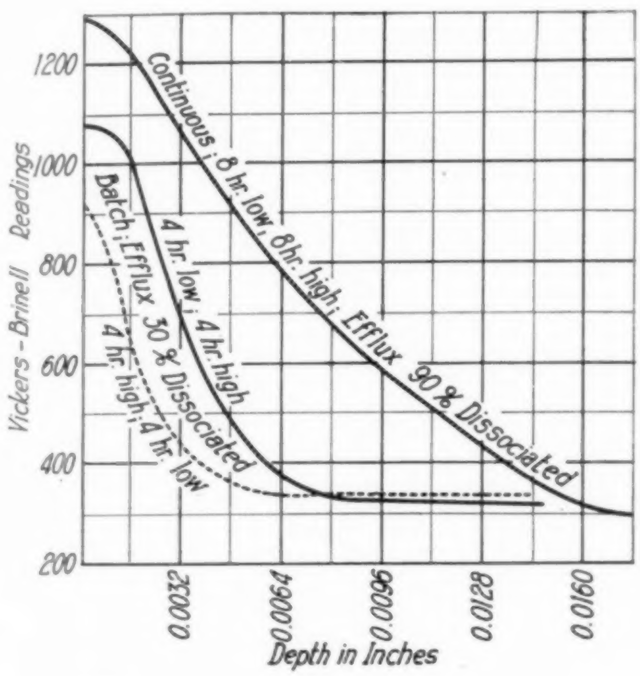


Figure 4
Continuous Nitriding for 16 Hours Gives Superior Surface Hardness and Penetration

It is interesting to compare the curves on this sheet. An 8-hr. treatment with a constant ammonia dissociation of 30 per cent gave very poor results in comparison with the 16-hr. continuous process. Comparison can also be made with Fig. 1, for a 48-hr. cycle. Results with continuous nitriding (top curve of Fig. 4) for 16 hr. with an ammonia dissociation at the outlet of 90 per cent are superior to those obtained by any constant dissociation (Fig. 1) maintained for 48 hr. This is strong proof that the new process is scientifically sound.

The next question that naturally arises is "Would better results be obtained if, in the continuous process, we were to maintain a lower dissociation at the outlet — say 40 per cent, rather than 90 per cent?" To investigate this matter, some work was done using the same heat cycle for each test but changing the dissociation. These results are shown in Fig. 5; the two curves are so nearly alike as to be almost indistinguishable. The work was repeated at higher temperature with similar results.

This points to a conclusion of great practical value. It shows that the ammonia may be used completely in this process without danger of impairing the work. Such practice is impossible by any other method, as is shown by reference again to Fig. 1, where ammonia, dissociated 62 per cent, gave very poor results in a batch type process.

Correct Temperature Cycle

After deciding on the degree of dissociation desirable for continuous nitriding, a study was made of different heat cycles to determine which one would give best results by this process. It would seem that a gradual increase in temperature from the inlet to the maximum temperature desired would be more in harmony with progressive dissociation of ammonia and the continuous nitriding reaction than the reverse. If the highest temperature were met at the beginning, there would immediately be a very rapid ammonia dissociation at the inlet, which would no doubt be too rapid for all the nitrogen to be absorbed by the metal. The decreasing amount of ammonia dissociating during the subsequently decreasing temperature would not assist in further nitriding, so that the ammonia would not be used to good advantage even though it were completely dissociated at the outlet. To prove this point a third line is shown in Fig. 5 which plots the results obtained when the high temperature treatment was given first, and a dissociation of 90 per cent was maintained. It is evident that the low-to-high temperature cycle produces best results when used for continuous nitriding.

The character of case desired determines the arrangement of the heat zones. In this regard the continuous method is particularly flexible. A very hard case may be produced by lengthening the low temperature zone with the consequent shortening of the high temperature zone, whereas a tough case with greater penetration may be produced by placing the high temperature zone first and the low temperature zone

last in the cycle. By varying these zones, both as to their order and relative length, it will be possible to obtain any particular result that may be desired.

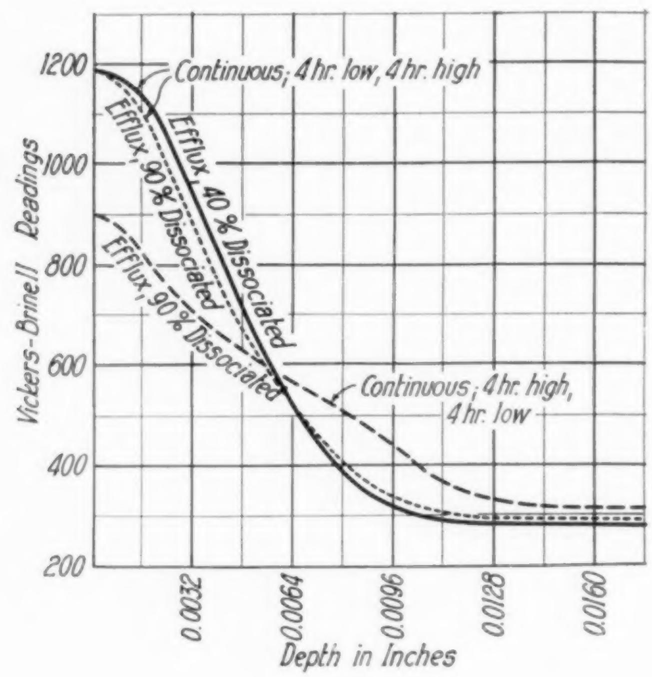


Figure 5
Ammonia Can Be Entirely Consumed Before it Must Be Discharged From Continuous Retort

It is believed that the continuous nitriding system is alone in possessing these features and that by these means many of the present erratic results may be completely avoided. We look forward with much interest to subsequent developments along these lines, for by these means the metallurgist is now given a control over the process heretofore unapproached.

These results may be summarized as follows:

(1) The batch type process cannot produce satisfactory work with an ammonia dissociation greater than 50 per cent.

(2) This is due to high hydrogen concentration, which causes excessive decarburization.

(3) High hydrogen concentration does not affect a previously nitrided surface; therefore, if nitriding is conducted so as to bring nothing but fresh ammonia into contact with new metal surfaces the danger of high hydrogen is eliminated. (By "new metal surfaces" is meant those intended for nitriding.)

(4) This can be done only by continuous nitriding, where the ammonia moves along the muffle in the same direction as the work. This fact forms the basis of the continuous process.

Economics of Continuous Operation

(5) By this means it is possible to use almost all of the ammonia admitted to the system. A dissociation at the outlet of 90 per cent is good practice.

(6) An arrangement of successive temperature zones that may be easily controlled makes it possible to obtain different types of cases at will.

(7) Considerable time is saved by this process. Work done in 16 hr. compares favorably with that done in 48 hr. by usual methods.

(8) The consumption of ammonia is very much reduced with the consequent saving in this item of cost.

With the development of this process and of the means to carry it out we feel that the furnace industry has met the challenge for better equipment in a satisfactory way. The search for better equipment has required a further study of the fundamentals. As usual, this has uncovered the weak places in the current art, so that along with this better equipment can be offered an improvement in the nitriding art that indicates a distinct step in advance.

Recent Experiments with Gaseous Cements

Carburizing with Propane

ONE of the most interesting papers read before the twelfth annual convention of the American Society for Steel Treating, held last month in Chicago, was by Messrs. O. J. Wilbor and J. A. Comstock, and recounted some of their recent experiments on the effect of various gases and mixtures of gases on steel at furnace temperatures.

They point out that the reactions between a gas and hot steel vary with the temperature and the pressure or the concentration of the gas. At heat treating temperatures and atmospheric pressure, hydrogen and carbon monoxide will deoxidize steel, and consequently, are useful for bright annealing; however, hydrogen will also decarburize high carbon steel, but pure carbon monoxide generally is a carburizer. Oxygen, carbon dioxide and steam form scale on steel and also decarburize it at temperatures above the critical point. Nitrogen is neutral. Methane and other simple hydrocarbons partly break down into carbon and hydrogen and consequently may either decarburize or carburize, depending on circumstances.

It does not follow that mixtures of simple gases will act the same in the presence of other gases as they do alone. The result will depend on a number of factors, among which the authors note: (1) the volumetric ratio of the component gases; (2) temperature; (3) pressure; (4) rate of flow; (5) character of the components; (6) kind of metal being heat treated.

How these factors affect the decomposition of a hydrocarbon gas, such as propane, is discussed by the authors. They show that:

(1) Decomposition results in a mixture of solid carbon, gaseous hydrogen, and unaffected propane.

(2) Relatively more propane is decomposed as the temperature goes up, but relatively less at higher pressures.

(3) Increasing the rate of flow generally increases the carbon deposition.

(4) Adding hydrogen, carbon dioxide, oxygen, or steam to the hydrocarbon will decrease the deposition of carbon.

(5) Carbon monoxide, added to the hydrocarbon gas, will increase the carburization.

The authors recommend pressures of about 15 lb. per sq. in. This slows down the dissociation of the hydrocarbons, and promotes a more uniform case on the steel when using less gas.

Intermittent Surge Process

A method known as the "intermittent surge process" is also useful for controlling the dissociation of hydrocarbons. The micros show the penetration (at 15 diameters) obtained in five steels after a series of runs of this nature.

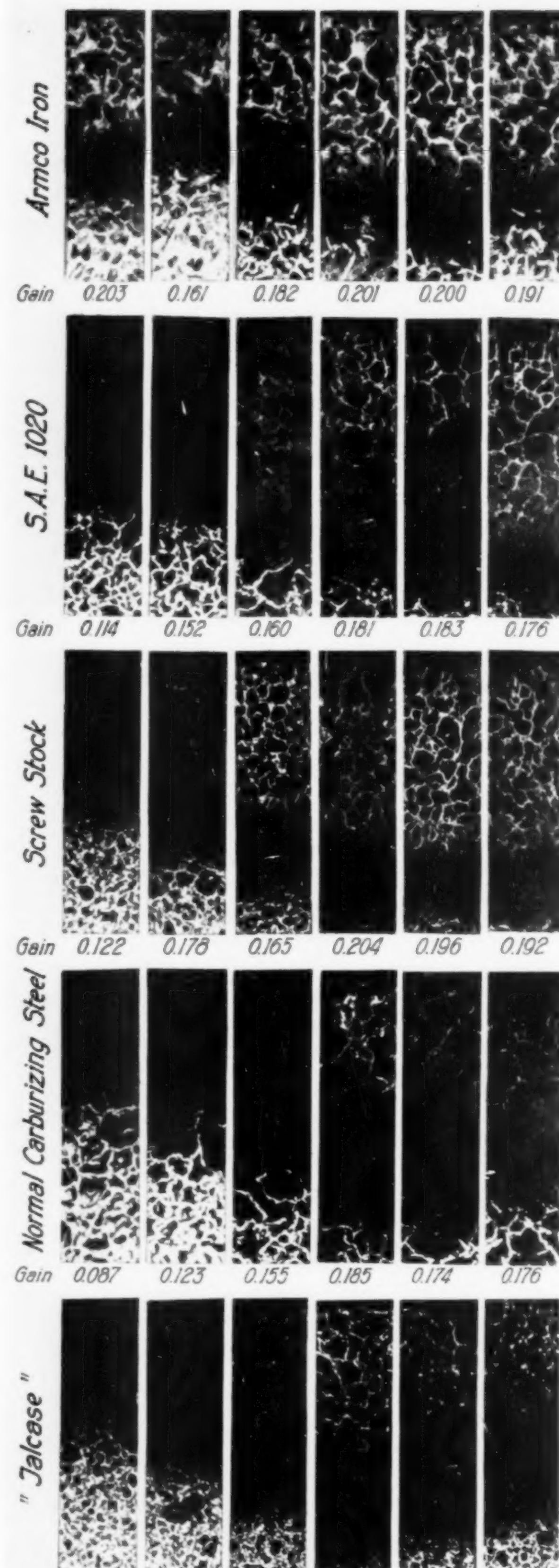
Uniform samples of such steel were placed in a tube furnace, connections made to gas supplies and exit joined to an analytical train. Temperature was raised to the carburizing heat: 1800 deg. Fahr., and the apparatus purged with wet CO_2 for 15 to 20 min. Into this atmosphere, which is a scaler and a decarburizer, were then admitted alternately dried propane gas and wet CO_2. These admissions were made at a surge pressure of 6.4 lb., and took only a few seconds. In this manner a turbulent flow at high speed was followed by an interruption of some minutes, which is a condition found best for carburizing by heavy hydrocarbon gases.

The routine for test No. 166, for instance, was an admission of 50 cc. of dry propane during 5 sec. and then a rest of 10 min. Thereupon 30 cc. of wet CO_2 was admitted during the short space of 7 sec. After a further lapse of 20 min. the second flow of propane was made, and so on.

During the time that the atmosphere consists primarily of propane, a certain quantity of that gas breaks down into sooty carbon and hydrogen gas, the former of which is available for carburization. A continuous flow of butane, however, would form prohibitive amounts of soot and greatly interfere with the efficiency of the carburizing gas, even though the pressure (which counteracts this dissociation) were high. Consequently the hydrocarbons are periodically displaced by CO_2. During this time the authors believe that "the steel continues to diffuse the carbon from the surface inward, and at the same time the surface will be prepared by the secondary gas to be in a receptive condition for the next surge of carburizing."

Quantitative Carburization

Experiments are described showing that it is possible to carburize steel parts at a definite carbon concentration for a given case depth. Gases used were various mixtures of city gas with hydrogen, nitrogen, carbon dioxide, or dry flue gas. The furnace temperature was a constant: 1725 deg. Fahr., and the time was usually 3 hr. Rate of flow was a variable. Cases produced were hypoeutectoid, eutectoid or hypereutectoid, as desired.



Gain	0.085	0.111	0.137	0.168	0.155	0.146
No.	163	164	165	166	167	168
Alternations	10	15	20	30	20	30
Min. on gas	30	20	15	10	15	10
*Gas injected	50cc.	50cc.	50cc.	50cc.	100cc.	100cc.
Min. on CO_2	90	60	45	20	15	10
CO_2 injected	30cc.	30cc.	30cc.	30cc.	30cc.	30cc.

Correspondence and Foreign Letters

Italian Industry Rapidly Developed

ITALIAN metallurgical industry, when compared with that of the other industrial countries, shows very peculiar characteristics, both as to its present situation, and to the conditions under which its very rapid development is actually taking place.

In order to comprehend this situation — which I expect to develop in subsequent letters — it is necessary to examine briefly the origins of Italian metallurgy.

While technical progress and the commercial development of metallurgy have taken place in all other industrial countries concurrently with the progress and the development of the mechanical industry (which is certainly the most important consumer of all typical metallurgical products) the Italian mechanical industry had expanded to notable proportions and reached a high technical standard, long before the very existence of any important metallurgical plant!

The only exceptions to this general statement were the Terni armor plate works, and the gun factory erected in Pozzuoli, near Naples, by the British firm, Armstrong, Whitworth & Co. But these two works specialized strictly in the manufacture of armor plate and ordnance, and never supplied more than incidental and extremely small qualities of the raw materials and semi-finished products (such as pig iron, steel ingots, shapes, rolled bars, castings, sheets and tubes) required by Italian shipyards and machine shops. Consequently, we imported from other countries practically all the metallic raw materials and semi-finished products needed for machines, structures, tools, implements and utensils made within our borders.

As a consequence of this peculiar situation, the first Italian metallurgical works to be erected had immediately to fight for their own national market against the very strong competition of the largest foreign metallurgical concerns. These foreign competitors had long ago reached a very high degree of technical and industrial efficiency, and also had established very powerful commercial organizations in Italy, perfectly acquainted with the problems and personnel of the Italian shipyards and engineering works.

Under such conditions, it is easy to understand what enormous difficulties were confronted by the new Italian metallurgical concerns.

Perhaps the greatest of these difficulties arose from the necessity of developing their plants immediately to a very large size, in order to compete with foreign works on a price basis. Of course, the iron and steel producers in England, Germany and the United States had reached their present and full development only after many years, during which they had had ample opportunity to develop and improve their plants, and gradually to form and instruct excellent technical staffs, highly specialized in the different technical problems.

The new Italian concerns could not start on a small output. In such an event, their costs of production would have been too high to compete with those achieved in the foreign works, whose large production, sold on many markets, enabled them to sell in Italy at "dumping" prices (as they practically always did). Nor could the Italian steel industry limit — at least at the beginning — the number of their products. The Italian mechanical concerns, which were already highly developed and specialized, would never leave the foreign sources of supply for the local ones, if the latter were not prepared to supply them with practically all the products they required.

In addition to these difficulties (and as a consequence of them) the new Italian metal industry was immediately confronted with another serious problem of rapidly training a technical personnel in proportion with the importance of the new works. *(Cont. on p. 104)*

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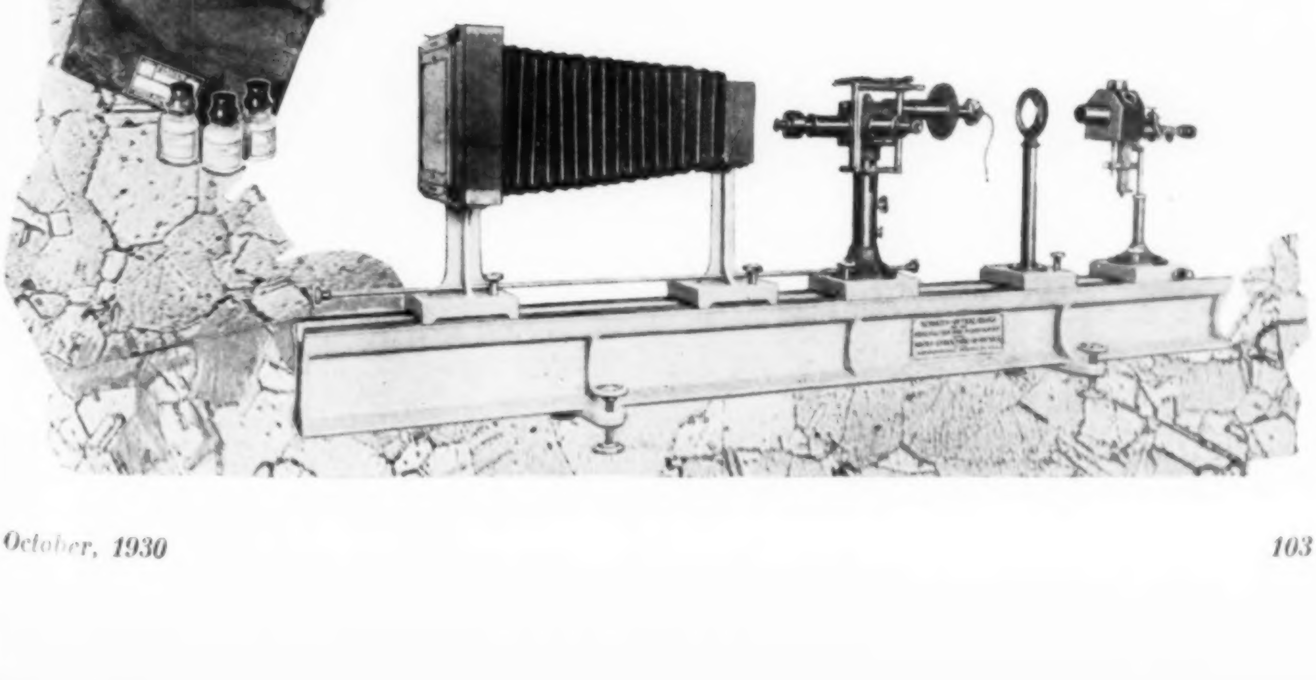

Correspondence

At present it can be said that the greatest difficulties have been overcome. The Italian metallurgical industry has entered a period of rapid and sound development, both technical and commercial, which I hope to have the opportunity of describing in future letters.

FEDERICO GIOLITTI,
Turin, Italy.

Sponge Iron Produced In Sweden

DURING recent years a shortage of high grade scrap in Sweden has tended to increase the cost of steel made by the acid open-hearth process. As this situation might also imperil the quality of the steel, the problem of producing a cheap and first-rate sponge iron as a substitute for scrap metal or pig iron has become of prime importance to us.

Over 20 years ago the production of sponge iron was started at Höganäs, where is located the only coal mine in Sweden. The method, which is still in use, was invented by Sieurin. He found that a rich concentrate of iron oxide mixed with lime and low grade coal gave a good sponge when heated in fire clay containers placed in annular furnaces. The product contains about 95 per cent iron and, being very low in sulphur, can be converted into excellent steel. Total production by Sieurin's method is not very large, amounting only to about 6000 tons a year; of this about one-third is exported, the United States receiving the trifling quantity of about 500 tons.

Several methods of making sponge iron have been suggested during recent years, but I believe all are still in what may be called the experimental stage. In Scandinavia the attempts to solve the problem have been mainly along three different lines. (Cont. on page 106)


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Foreign Letters

M. Wiberg has suggested a method of treating the iron ore (in the form of lumps or briquettes) in a shaft furnace or rotary furnace with charcoal gas at a temperature of about 1000 deg. C., using the counter-current principle. The most valuable feature in this process is that the main part of the gas is taken out of the furnace immediately after having passed the zone where the reduction of FeO into Fe takes place, and is regenerated in a carburetor system before passing through the furnace again. The rest of the gas passing through the remainder of the furnace still has enough reducing capacity to bring about the reduction of Fe_3O_4 into FeO. The heat content of the residual gas is then used for preheating the ore. This theoretically sound process has been described before the American Electrochemical Society in 1927, and on being tested on a small scale, has been found to give a good product. Some of its important operative details, however, still remain to be solved.

The method of the Norsk Steel Co. is based upon the reduction of iron oxide by means of carbon monoxide and hydrogen. The gas mixture is regenerated thermally in a high tension electric arc, and chemically in a coke generator. The ore is reduced in a rotary furnace. The process is intended for poor ore, and the end product has to be concentrated magnetically. The method was suggested by the Norwegian metallurgist, E. Edwin, and has been tested in Nidaros, partially through the initiative of the Lappland iron ore miners, the Grängesberg-Oxelösund Co. Experiments along the lines suggested by Edwin are also being carried out in Germany.

Quite recently B. Kalling of the Avesta Steel Works has attempted to make sponge iron by heating electrically a mixture of concentrate and charcoal powder in a rotary furnace. At a metallurgical meeting held during the spring, he communicated some results obtained, from which it seems that the experiments are promising. *(Continued on page 110)*

Correspondence

In addition to the three methods of making sponge iron mentioned above, another matter that is of great interest at present is the direct production of steel by the process invented by Flodin and Gustafsson. Briquettes of rich ore and powdered charcoal are heated in an electric arc and the steel formed is collected on a hearth. After a sufficient quantity is produced it is transferred to another furnace for final refining.

A small plant of this type has very recently been erected at Längshyttan, where it is used mainly for the production of high chromium steel. The process requires much energy and will probably need very cheap electric power to be successful in commercial competition with other methods of making ferro alloys and alloy steel.

A. Westgren,
Stockholm, Sweden.

Chrome Refractories Cheapest In the End

WHILE agreeing thoroughly with Mr. Kielman on the many points concerning furnace design he so capably covered in the article in Metal Progress for September, I would question one statement on page 61 that "A neutral or basic refractory, like chrome brick or plastic chrome ore, will resist the scouring action of hot scale, but such material is expensive."

While it is true that plastic chrome ore materials cost more than fire brick or sand, in the long run this material is really the cheapest. This statement was made (and the reasons for making it were stated) in the advertisement of E. J. Lavino & Co., printed on page 129 of the same issue.

We are of the opinion that it would have been more nearly correct to say that the first cost of such products is high, but in the long run they are really cheaper than material used in the past for hearths in forging and heating furnaces.

A. deMacedo,
E. J. Lavino & Co., Philadelphia.

Hardenability of Tool Steel

DURING a trip last summer through many European countries, I found a great deal of attention was being given to the hardenability of tool steels and its control by regulating the melting procedure. European manufacturers feel that the hardening test cannot be used to compare the product of different manufacturers, but is a useful control for steel made in a particular plant.

In Sweden the test appears to have been standardized as follows: Five samples, 20 mm. square by $8\frac{1}{2}$ cm. long are hardened in saturated brine from a lead pot at 770, 800, 830, 860 and 890 deg. C. Each sample is broken and the fracture classified on the basis of fineness. The quality index number is obtained by adding the fracture number of each of the samples.

Samples for the test are rolled from the billet in a small mill set up for this particular purpose. After rolling, the pieces are annealed in air at 30 to 50 deg. C. above the critical temperature.

Swedish mills have generally accepted the fact that a fine grain fracture after hardening at high temperatures is an indication that the steel will be a shallow hardening steel at normal quenching temperatures.

In Czecho-Slovakia the test piece for hardenability is 20 mm. square by about 3 in. long, hammered from the billet. Practice there is to use nine normalized specimens, and harden in brine from lead at 720, 740, 760, 780, 800, 820, 840, 860 and 880 deg. C. Specimens are nicked before hardening with a 60-deg. sharp bottom Vee, 2 mm. deep, and broken after hardening. The same test is made on an annealed piece of the same bar after machining on two sides to 20 mm. *(Continued on page 114)*

Correspondence

Temperature at which hardening begins is noted. (In plain carbon steel this starts, as a rule, at 720 deg. C., although the center is not yet refined.) At 740 deg. C. the case and core are both refined in good straight carbon steel. An open-hearth steel may harden at 700 or even 690, but such a low temperature is considered a sign of poor quality.

The highest temperature giving refinement to the outside is the top of the hardening range, which range is the most important basis for judging the heat. It is also common practice to measure the depth of the hardened layer on the center of a machined side, and this must be constant for the hardening range. In annealed bars the hardened layer is slightly thinner and the hardenability range a little wider than in the normalized bars. This distinction is more noticeable in open-hearth steels.

These tests are used regularly to check two or three heats daily, and for certain uses classifies the heats according to quality — extra best, best, and no good. My informants stated that depth and range of hardenability can be regularly controlled at no extra cost, and this practice has been pursued for at least ten years. Two per cent manganese steels have been made which harden no deeper than ordinary tool steel.

It is also common practice for this Czecho-Slovakian firm to furnish ordinary carbon tool steel with hardenability corresponding to the section and use which is to be made of the material. This is standard practice with my own company (Ingersoll-Rand Co.), as we use the hardenability test described in *Transactions* A.S.S.T., for January, page 30, to regulate the use of materials and to control the purchases.

B. F. Shepherd,
Phillipsburg, N. J.

Japanese Study Age Hardening

SINCE vanadium steel is very useful from an industrial viewpoint, I take pleasure in sending you the results of some fundamental investigations of great value, in the form of an equilibrium diagram of the iron - vanadium - carbon system. (This is reproduced on the data sheet, page 83.) During the last four years, Masakichi Oya, a member of our Institute, has been working on this ternary system.

His results are contained in five papers, three of which have already been published in *Science Reports* of our University, and the other two are now in the press. They are entitled as follows:

(1) X-ray analysis of iron-vanadium alloys;

(2) An investigation of the vanadium-carbon system;

(3) On the equilibrium diagram of the iron-vanadium system;

(4) Metallographic investigation of vanadium steels;

(5) On the equilibrium diagram of iron-vanadium-carbon system. *(Cont. on page 116)*

Foreign Letters

The summarized result of these papers are given for the first time in the diagram mentioned.

Sadajiro Kokubo and the present writer have been studying several properties of quenched aluminum-copper alloys during tempering with a view to clarify the mechanism of *age-hardening*. Specimens containing from 0 to 12 per cent copper were heated for 30 min. at 545 deg. C. and then quenched in water. After aging them for 10 or 20 days at room temperature, each of them was heated for 6 days at different temperatures up to 500 deg. C.; they were then slowly cooled in the furnace, and at each stage their density, electric resistance and hardness were measured. The dilatation and thermal curves were also taken for quenched specimens.

The observed facts do not agree with conclusions drawn from the precipitation theory of Dr. Paul D. Merica and others. We have formulated a new theory modified from one suggested by Dr. S. Konno.

We believe that the hardening, which increases in intensity up to an annealing temperature of 170 deg. C., is due to the lattice distortion caused by the copper atoms, which just before the precipitation of $CuAl_2$ from the aluminum solid solution, move towards grain boundaries and concentrate there within the lattice of aluminum. A further annealing at higher temperature results in the precipitation of the compound and the consequent softening of the alloy. A paper on this subject was read at the Liege Congress, June 24.

From the secretary of the Franklin Institute, Philadelphia, I have received a letter saying that the Elliot Cresson Gold Medal will be bestowed upon me May 20, 1931. This is not only a great honor to me, but also to our nation. It will give me much pleasure to visit America again, and to receive the medal personally.

K. Honda,
Sendai, Japan.

FREDDY REPORTS TO THE BOSS

by Hal Chase

Ed. note: Freddy has been run for several years in Alloy Arguments, the house organ of General Alloys Co. (now discontinued), in Heat Treating & Forging. Freddy is a mythological peddler working for the Porous Castings Corporation, a nebulous steel foundry philandering in the alloy business. Freddy is so lowbrow you wonder how he gets across. If you don't like Freddy make all complaints to Hal Chase.

ATLANTIC CITY, N. JOISEY, One of those mornings.

Frend Gawge:

Here I am spendin a hole week at this connection wich was one time the play grounds of the non laborin plutes, the bloated bond holder mob, the T. B. M., or quick here comes my husband tell him you're my brother. The bored walk, wich it used to be a indication of heavy ashcay to go trottin on, now gets the daily and nitely vibrations from the fallen arches of a lotta the boys who will deliver it to the room for a eight buck drop, and the high heel puppies of plenty female miners who don't shoulder no pick and shovel, either, Gawge.

PLENTY OF FEMALE MINERS

Met a tomater last eve who runs a coupla shush places. He calls one hideout left ankle and the other one right ankle because he says that everyone knows that they are a coupla low joints. This guy comes up to the room last nite and gives me a bid to a party wich starts in a high class gin mill and ends up in a swell Apt. they was all kinds of peepul there. The canary who runs the joint is a palooka named Dailey, which I understand is a desendant of the guy what invented the Dailey papers. He has his tongue hangin out to represent a neck-tie and talks mezzo soprano but reely seems to be the kind of a guy who couldn't rave about a pair of silk stockins unless they had somethin in them. He asks me if I am havin a good time and I murders him with the crack that I had too much will power to have enny fun at a party. They was plenty of eye widenin bimboes there, too. The party runs outta tonsil dissolver durin the midst of the racket so the host sends a guy out for some whiskey and lemons. He sent the B. L. around five minutes later with the oozbay but it took him a coupla hours to find the lemons. What a village this is, Gawge.

Chester's brother is workin down here and he takes me around to see some of the boys. Speekin of noses runnin in families, Gawge, I should say that dizzy skulls is also in the same class. This guy is so dizzy it's a wonder he aint been bumped off from the effects of centrifugal force. We got into a dice pitchin contest with the gang and about nine o'clock he calls up Schultz the butcher.

DON'T NEED A MURAD TO BE NONCHALANT

"Say," he yelps into the phone, 'is this the meat store?"

Schultz tells him it certeny is.

"Well," says the goofer, "go down to Marten's and meet my wife for me. I had a date with her at eight o'clock."

He thinks Lou Gehrig on the Yankees is a shoemaker. He says he reaa in the paper the other day where he made a coupla costly boots. He's the kind of a egg who don't need a murad to be nonchalant whilst coolin his soup by fannin it with his hat. A dizzy tomater, Gawge, a dizzy tomater. He married a dame without any legs because his back is sensitive to cold feet. He tumbles me to a swell lookin dame who I goes on the make for rite away. I went beechin with her the next eve. She's the kind of a broad you don't know whether to call dumb or innocent. She tells me she was brought up on a farm and she still thinks that a pet shop is a neckin establishment.

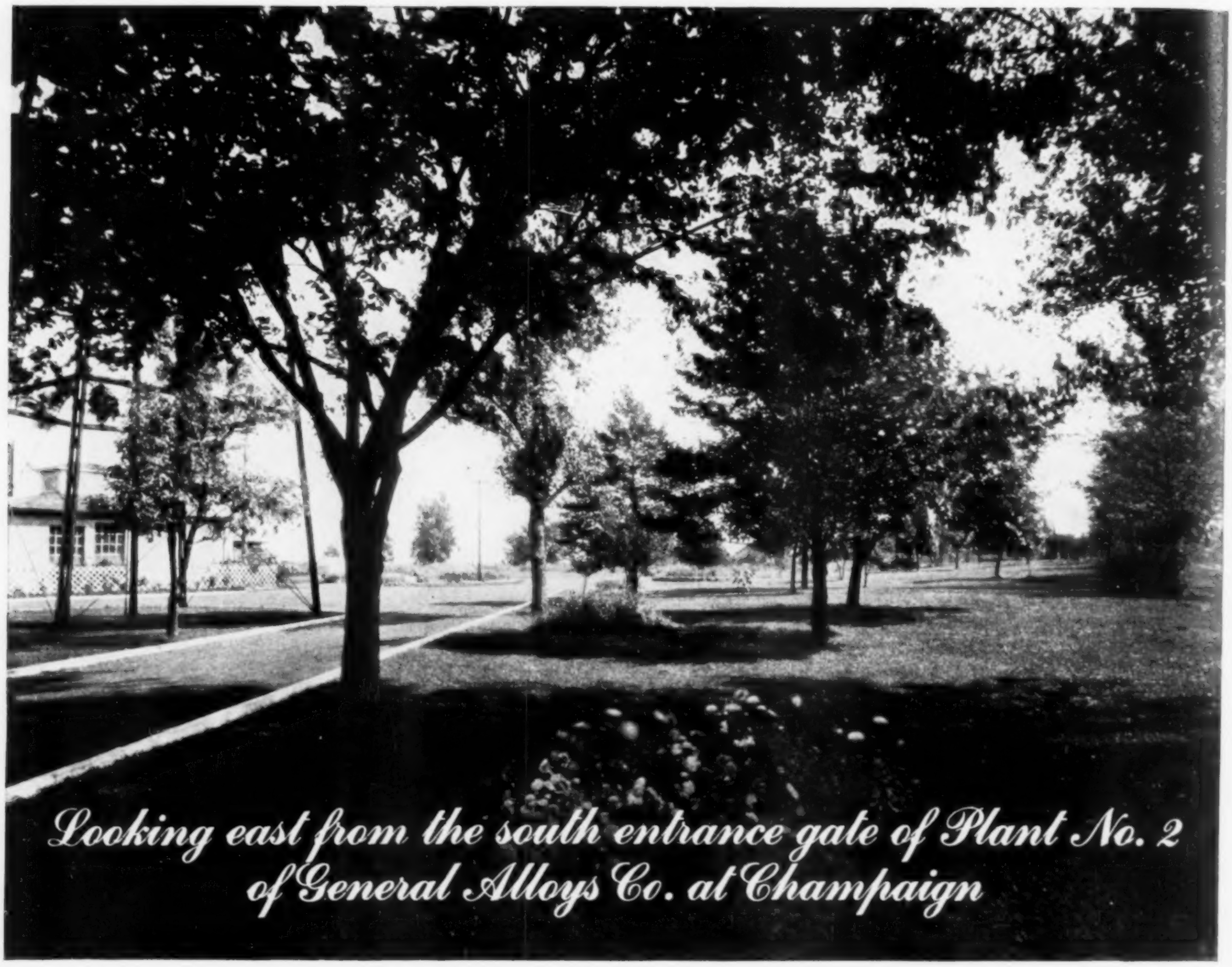
TOO MUCH WILL POWER TO HAVE ANY FUN ~

Well, old pal, as the guy sez when he pushed the last of his chips into the middle of the table, "I'll be seein you."

Yours till that dizzy girl frend of yours in Peoria stops straining coffee through the fly swatter.

Freddie.

P. S. Kinder tough about all those furnace rails failin wich we furnished for that steel company in Pittsdirt, Pa., but I see by the stock market reports that all rails have been very weak for the last six months, Gawge. F.

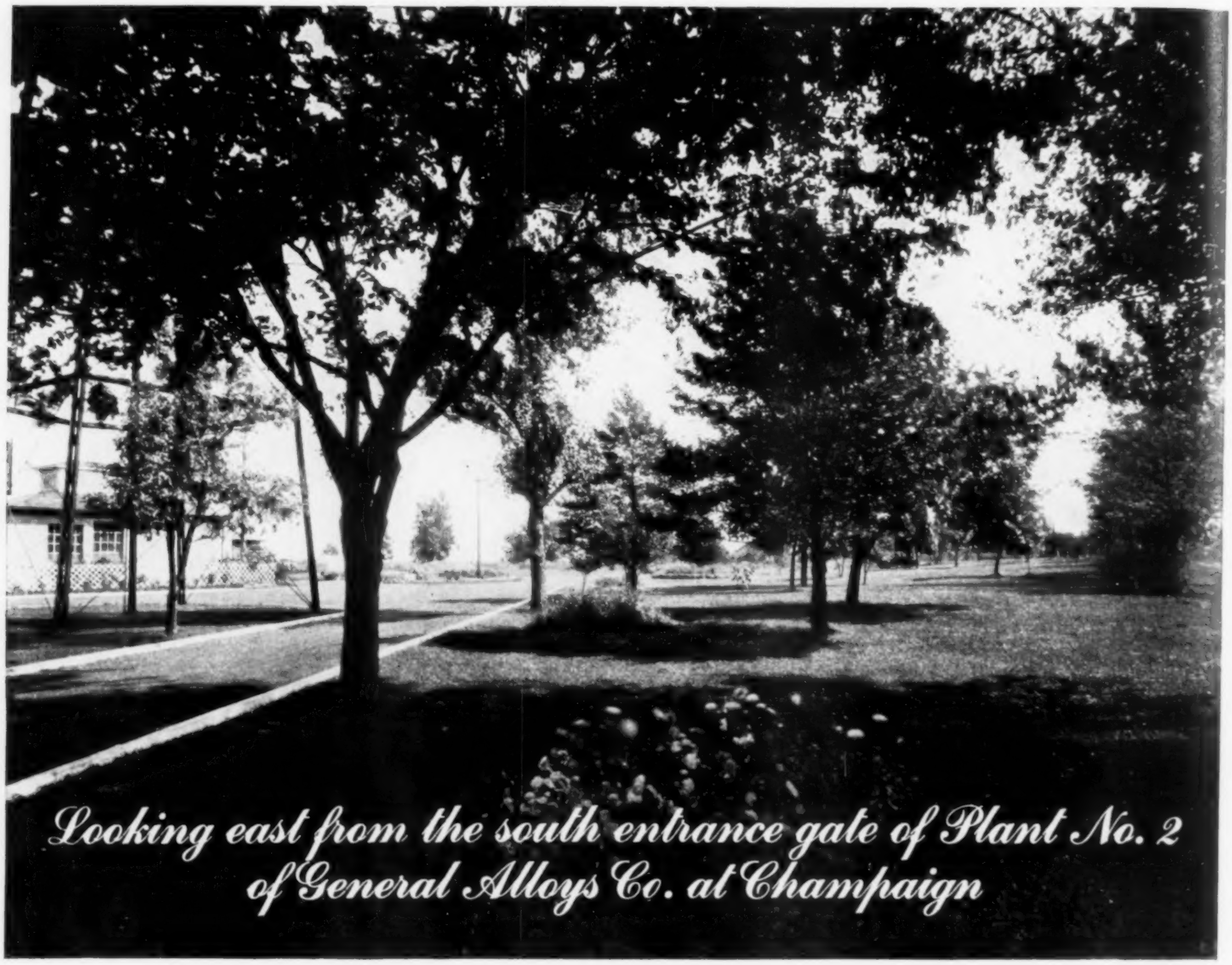


A PLANT IN A PARK. . . . . A Sunshine plant, white—silver—mostly windows . . . . . eighty thousand primroses . . . . . young ivy climbing . . . . . ramblers rambling . . . . . 14 misspelled words in 268 employment applications from 100% native born Americans . . . . . Airport at door . . . . . Blackberries ringing slag dump . . . . . Trees—birds . . . . . Birds—trees . . . . . Children picking flowers.

\+ + +

A PRODUCT reflecting the character of its makers, whose vision and ability have established those standards by which men judge all contemporary products.

ALLOYS PROGRESS PAGE VIII



Looking east from the south entrance gate of Plant No. 2 of General Alloys Co. at Champaign

A PLANT IN A PARK. . . . . A Sunshine plant, white—silver—mostly windows . . . . . eighty thousand primroses . . . . . young ivy climbing . . . . . ramblers rambling . . . . . 14 misspelled words in 268 employment applications from 100% native born Americans . . . . . Airport at door . . . . . Blackberries ringing slag dump . . . . . Trees—birds . . . . . Birds—trees . . . . . Children picking flowers.

+ + +

A PRODUCT reflecting the character of its makers, whose vision and ability have established those standards by which men judge all contemporary products.

ALLOYS PROGRESS PAGE VIII

Around the World With Metal Progress

Mine La Motte, in Southeast Missouri, yields 1,000 tons of lead a day. Fernando de Soto mined copper from it in 1541.

Smaller silver dollars will be popular and bring needed increased demand for silver, says Nevada senator, chairman of committee on mines and mining.

Nineteen stories high, a new office building in Dallas, Texas, is the tallest structure so far to be 100 per cent electrically welded.

Twelve million tons of rich hematite ore are reported to have been discovered near Nipigon, Ontario, only 500 ft. below ground.

Almost 300,000 tons of steel took a river ride in the Pittsburgh district last month. Ohio, Monongahela and Allegheny River shipments are breaking records.

The first highway with a steel foundation is being built in Sangamon County, Illinois. Sand, brick and asphalt lie above the sheet of steel.

South America is mineral-rich; its 1929 production was valued at over $562,000,000. The 13 countries produced 17 metallics and 9 nonmetallics. Chile lead them all by producing $297,000,000 worth of nitrate, copper, iron ore, gold, silver, manganese, sulphur, coal, lead, borax and iodine.

A link of "ye mightie chaine of yron" which was stretched across Portsmouth Harbor, England, in 1522, has been found in good condition after its 408-year bath. The chain was originally buoyed across the harbor mouth by three barges as a defense against invasion from the sea.

Magnesium alloys represent 50 per cent of all light metals used in German aircraft today. Reduced price is the explanation, say Germans who know.

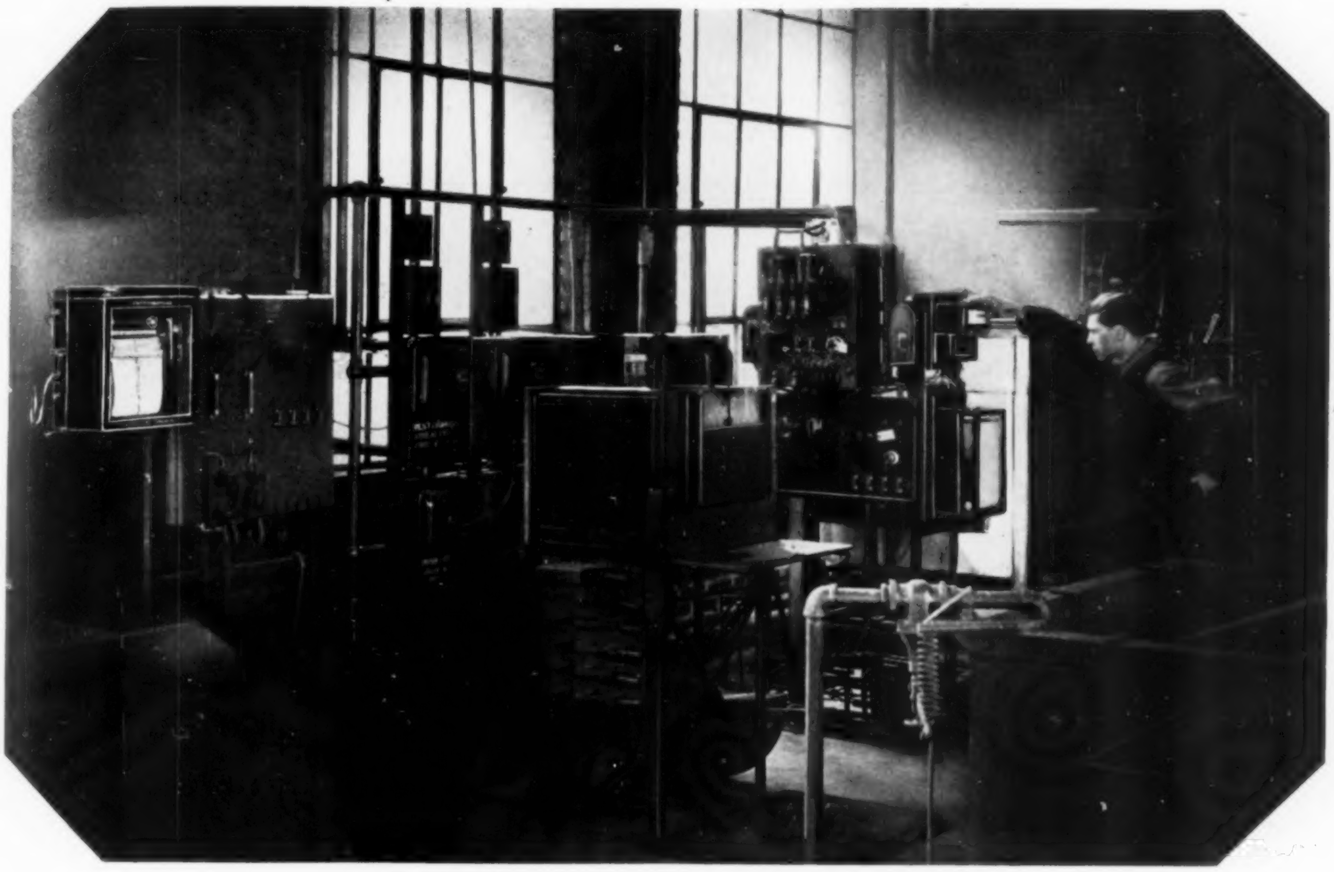
Nine waterwheel-driven generators, the world's largest, will supply power for southern U. S. S. R. Four are nearing completion in Schenectady.

Turkey wants a new railroad and is spending $12,000,000 with German interests for raw materials to build it. Construction costs extra.

Modern can making machinery would help eliminate China's famines. Produce raised in fertile sections could then be supplied cheaply to famine areas.

Japanese pig iron producers worry over imports of 100,000 tons of Indian pig iron while their own sales dwindle. They ask a high tariff.

A $6,000 gold nugget has started a new gold rush in Australia. Prospectors use autos now to get to gold fields, dispatches say.



Brown Indicating, Recording & Automatic Control Pyrometers at the Millers Falls, Mass., plant of the Millers Falls Company.

to Go a Long Period.... *without Attention"*

An Important Pyrometer Characteristic!

BETTER HEAT TREATING helps the Millers Falls Company to uphold their good name ... their reputation for quality tools ... helps them to make their tools faster, better and at a lower cost. • The letter on the opposite page proves that Brown Pyrometers and Automatic Temperature Controls give the kind of service needed in your shop ... in every shop. • No matter what your work or your furnaces, Brown Pyrometers and Brown engineers can give you the temperature control that fits your job.

Write for information ... engineering recommendations ... quotations. Prompt service without obligation.

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4503 WAYNE AVENUE • • • PHILADELPHIA, PA.
BRANCHES IN 20 PRINCIPAL CITIES

Temperature Controls

TO ECONOMIZE

Reviews of Recent Patents

by Nelson Littell

Patent Attorney — **475 Fifth Avenue, New York** — **Member of A.S.S.T.**

Metal for Valves, *by Camille Contal, St. Cloud, France. 1,771,773; July 29.*

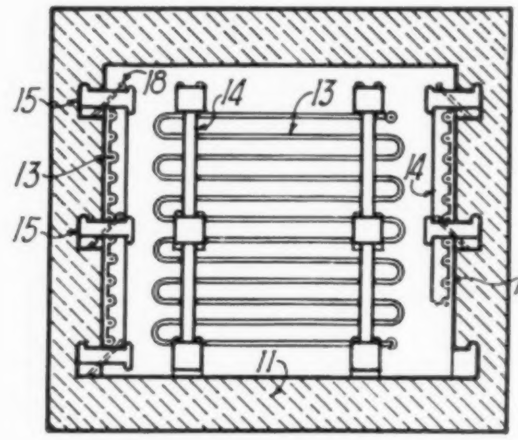
The present invention has for its object a non-oxidizable alloy designed particularly for the manufacture of valves and other adjusting and packing members and to resist the action of heated steam. The alloy comprises nickel 40 per cent, copper 31 per cent, manganese 18 per cent, antimony 9 per cent, and tin 2 per cent. This alloy is preferably made from 30 per cent copper-manganese alloy which is first melted and to which nickel is then added. Subsequently manganese, antimony and tin are added and some borax to prevent oxidation.

This alloy has certain desirable characteristics such as a melting point of about 1000 deg. C. and a Brinell hardness of 210. It may be tempered, however, for machining. Boiling nitric and sulphuric acids attack the alloy only with great difficulty, and boiling potash and ammonia cause only an insignificant loss of weight.

Electric Furnace, *by Alvid D. Keene, of Pittsburgh, assignor to Westinghouse Electric & Mfg. Co. 1,763,239; June 10.*

This patent particularly relates to means for supporting an electric resistor unit, the support being mechanically locked to the walls of the furnace and removable therefrom. As shown in the figure on p. 138 the furnace walls *11* form a furnace chamber, and refractory resistor units *13* are supported by grooved refractory insulator members *14*. *(Continued on p. 138)*

The resistor unit is supported by a perforated cleated locking member *15* and a perforated wedging member locked together by pins *18*. To remove the resistor unit the pins are removed from the perforations permitting lateral movement of the resistor unit. Such movement



disengages it from the supporting members and the wedge members may then be withdrawn. The structure is claimed to be simple, readily removable, easily assembled, and a practical means for renewing damaged or destroyed resistor elements.

Lead Alloy, *by Sydney Beckinsale and Herbert Waterhouse, of Woolwich, London, Eng. 1,766,871; June 24.*

This invention has for its object to obviate the disadvantages attendant upon the use of pure lead for cable sheathing, pipe, sheeting and the like, chief of which is that the metal is liable to fail by inter-crystalline chemical attack, and also by a peculiar type of inter-crystalline disintegration due to the action of alternating stresses. It is known that the addition of cadmium increases the resistance to failure under fatigue and that antimony and tin also improve the mechanical and corrosion resistant properties of lead. The invention consists of an alloy containing lead and cadmium and one or both of the metals, tin and antimony, in the proportions up to 5 per cent and 3 per cent respectively. The ternary and quarternary alloys produced in accordance with the invention are susceptible to heat treatment, and if heated to a temperature to exceed 150 deg. C. and then quenched in water or rapidly cooled the hardness and tensile *(Continued on p. 140)*

ALABAMA, *Birmingham*,
Alabama Clay Products Co.
CALIFORNIA, *Los Angeles*,
Robert M. Hartwell Co., Inc.
CALIFORNIA, *San Francisco*,
F. W. Marwedel Co.
COLORADO, *Denver*,
H. W. Thompson
CONNECTICUT, *Hartford*,
Jackson & Seguine, Inc.
CONNECTICUT, *New Britain*,
Rackliffe Bros. Co., Inc.
CONNECTICUT, *New Haven*,
The Warner-Miller Co.
DISTRICT OF COLUMBIA, *Washington*,
Frice, Beall & Sharp Co.
GEORGIA, *Atlanta*,
Atlanta Textile Supply Co.
ILLINOIS, *Chicago*,
Wm. E. Dee Co.
INDIANA, *Fort Wayne*,
Harry A. Neff
INDIANA, *Indianapolis*,
Indianapolis Belting & Supply Co.
IOWA, *Des Moines*,
Walredh Supply Co.
KANSAS, *Pittsburg*,
Marshall Supply Co.
KENTUCKY, *Louisville*,
E. D. Morton & Co., Inc.
KENTUCKY, *Paducah*,
Henry A. Petter Supply Co.
LOUISIANA, *New Orleans*,
Woodward, Wight & Co., Ltd.
LOUISIANA, *Shreveport*,
Woodward, Wight & Co., Ltd.
MARYLAND, *Baltimore*,
Keasbey & Mattison Co
National Building Supply Co.
MASSACHUSETTS, *Boston*,
Waldo Bros. Company
MASSACHUSETTS, *Springfield*,
Oscar F. Carlson
MASSACHUSETTS, *Worcester*,
Waldo Bros. Company
MICHIGAN, *Detroit*,
The Rayl Company
MINNESOTA, *Duluth*,
Duluth Builders Supply Co.
MINNESOTA, *Minneapolis*,
Northern Machinery & Supply Co.
MISSOURI, *St. Louis*,
Handlan Buck Mfg. Co.
NEBRASKA, *Omaha*,
American Machinery & Supply Co.
NEW YORK, *Binghamton*,
M. E. Lewis Co.
NEW YORK, *Buffalo*,
The Curtis Supply Co.
NEW YORK, *Mohawk*,
American Hard Wall Plaster Co.
NEW YORK, *New York*,
C. C. Phillips, 110 W. 34th St.
NEW YORK, *Rochester*,
American Clay & Cement Corp.
Wm. Summerhays Sons Corp.
NEW YORK, *Rome*,
American Hard Wall Plaster Co.
NEW YORK, *Syracuse*,
Paragon Plaster Co.
NEW YORK, *Utica*,
American Hard Wall Plaster Co.
NORTH CAROLINA, *Asheville*,
John E. Thayer, Inc.
NORTH CAROLINA, *Greensboro*,
Odell Mill Supply Co.
NORTH CAROLINA, *Winston-Salem*,
Kester Machinery Co.
OHIO, *Cincinnati*,
Wm. T. Johnston Co.
OHIO, *Cleveland*,
Cleveland Tool & Supply Co.
OHIO, *Columbus*,
Westwater Supply Co.
OHIO, *Dayton*,
Klinger-Dills Co.
OHIO, *Toledo*,
Hixon-Peterson Lumber Co.
OKLAHOMA, *Tulsa*,
Marshall Supply Co.
OREGON, *Portland*,
General Power Supply Co.
PENNSYLVANIA, *Allentown*,
Morris Black
PENNSYLVANIA, *Bethlehem*,
Morris Black
PENNSYLVANIA, *Erie*,
O. C. Thayer & Son
PENNSYLVANIA, *Pittsburgh*,
Pittsburgh Supply Co.
PENNSYLVANIA, *Reading*,
Reading Foundry & Supply Co.
PENNSYLVANIA, *York*,
The Careva Company
RHODE ISLAND, *Providence*,
Read & Lundy, Inc.
SOUTH CAROLINA, *Charleston*,
Allen & Webb Co.
SOUTH CAROLINA, *Columbia*,
Columbia Supply Co.
SOUTH CAROLINA, *Greenville*,
Greenville Textile Supply Co.
TENNESSEE, *Memphis*,
Reed & Duecker
TENNESSEE, *Nashville*,
McCarthy, Jones & Woodward Co.
TEXAS, *Beaumont*,
Norvell-Wilder Supply Co.
TEXAS, *Corpus Christi*,
San Antonio Machine & Supply Co.
TEXAS, *Dallas*,
The Murray Co.
TEXAS, *El Paso*,
Geo. S. Thomson Co.
TEXAS, *Houston*,
Norvell-Wilder Supply Co.
TEXAS, *San Antonio*,
San Antonio Machine & Supply Co.
TEXAS, *Waco*,
San Antonio Machine & Supply Co.
VIRGINIA, *Lynchburg*,
Gorman L. Burnett, Inc.
VIRGINIA, *Norfolk*,
Empire Machinery & Supply Corp.
VIRGINIA, *Richmond*,
Southern Ry. Supply Co.
VIRGINIA, *Roanoke*,
Gorman L. Burnett, Inc.
WASHINGTON, *Seattle*,
Cragin & Co.
WASHINGTON, *Spokane*,
Consolidated Supply Co.
WISCONSIN, *Milwaukee*,
W. H. Pipkorn Co.
WISCONSIN, *Superior*,
The Speakes Company

Canadian Distributors

BRITISH COLUMBIA, *Vancouver*,
B. C. Equipment Co., Ltd.
MANITOBA, *Winnipeg*,
Railway & Power Engrg. Corp.
NOVA SCOTIA, *Sydney*,
Railway & Power Engrg. Corp.
ONTARIO, *Hamilton*,
Thomson-Gordon, Ltd.
ONTARIO, *Port Arthur*,
Wells & Emmerson
ONTARIO, *Toronto*,
Railway & Power Engrg. Corp.
QUEBEC, *Montreal*,
Railway & Power Engrg. Corp.

Foreign Distributors

ENGLAND, *London*,
Refinery Products, Ltd.
FRANCE, *Paris*,
Compagnie Technique des Petroles
HAWAII, *Honolulu*,
Marine Machinery Co.
NEW ZEALAND, *Auckland*,
Wilton Furnace & Coal Co., Ltd.

"Rolling Your Own"

Very few smokers, as you know, "roll their own" in these days of machine-mixed tobaccos and machine-made cigarettes. The sack is no longer found in every man's suit, and the well-known bull of the billboards guards the Holsteins instead of the highways. Today, the ready-made smoke has the call, just as the ready-mixed and ready-for-use high temperature cement is now the preference.

YET there was a time when the "dry" high temperature cement or bonding mortar was quite the thing. That you added your own water instead of paying the cement manufacturer for it seemed to be quite an economy.

But furnace operators gradually realized the fallacy of the saving. It was frequently more than offset by the cost of labor required for manual mixing on the job. They realized also the impossibility of proper and thorough mixing by hand. Results were not uniform because of the human element responsible for variations in water additions and mixing time. And inferior bonding mortars produced only inferior brickwork, short in service life, requiring frequent repair and involving excessive maintenance costs for refractories.

Today, furnace operators prefer "wet" (plastic) cement that comes ready-mixed and convenient to use—and we have been making it for nearly a quarter-century. ADAMANT, the *original* of all high temperature cements, is and always has been shipped in plastic form.

ADAMANT Fire Brick Cement is mixed in modern machinery built especially for the purpose. All component material additions are carefully made and accurately measured. Mixing time is more than ample, thus assuring a uniform, plastic product. No finer refractory cement can be obtained. Your specification of ADAMANT Fire Brick Cement is very definite assurance of long-lasting fire brick construction and minimum refractories expense.

Every one of our factory representatives is equipped with a Pyro Radiation Pyrometer which gives instant, accurate reading of the temperature in any or all parts of the furnace.

BOTFIELD REFRACTORIES CO.

World's Largest Exclusive Manufacturer of High Temperature Cements

Swanson and Clymer Streets
Philadelphia . Pennsylvania

ADAMANT

FIRE BRICK CEMENT

Other ADAPRODUCTS Include

ADACHROME Plastic Super-Cement

ADACHROME *Fines* ADACHROME *Aggregate*

ADAPATCH (fire brick in plastic form)

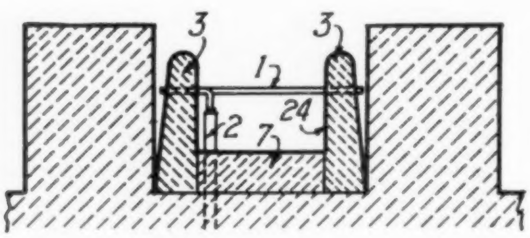
The ADAMANT Gun

Write for booklet

strength will be greatly increased. The preferred formula for a cable sheathing, formed from a lead alloy contains 0.10 to 2 per cent cadmium and 0.25 to 5 per cent of a metal from the group consisting of tin and antimony.

Heating Element Mount, *by E. L. Smalley, assignor to Hevi Duty Electric Co., of Milwaukee. 1,762,701; June 10.*

This patent relates to a construction for mounting the heating element in the bottom or hearth of an electric furnace, whereby the re-



sistor may be positively supported at several points and maintained in a predetermined position, both with respect to the lateral and vertical movement. Another object of the invention is to provide a refractory which is formed to allow the free release of heat upon that portion of the element covered by the refractory, and to eliminate the accumulation of scale and other foreign matter immediately adjacent to the resistor at the point of support. The resistor element includes wires *1*, mounted in the refractory *3*, spaced between the ledge *7* in such a manner that foreign particles, such as scale, may readily fall between the turns of the resistor to the surface of the ledge beneath. As the refractory support *3* is narrow where it engages the wire, the heat from the resistor unit may flow freely and the scale cannot collect and short-circuit the unit.

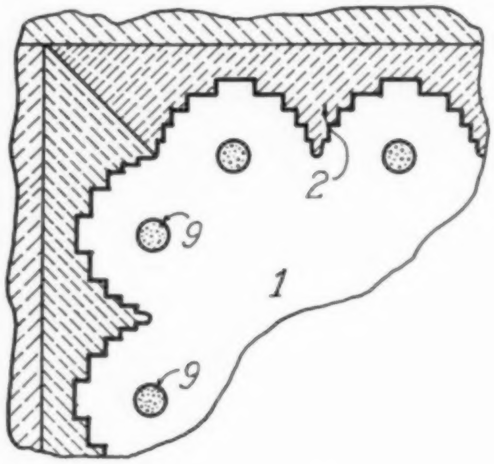
Hardening Machine, *by A. E. Shorter and C. L. Boucher, assignor to Patent Gear Hardening Co., London, Eng. 1,768,159 and 1,768,160; June 24.*

These patents describe machines for hardening irregular surfaces *(Continued on p. 142)*

of gear wheels, and the principal object of the invention is to provide a machine for uniformly hardening such irregular peripheral surfaces without distortion, and for heat treating a number of such articles simultaneously. Machines are provided with fixed high temperature heating devices, as well as means for rotating the articles to present successive portions of said surfaces to be heated and to maintain said surfaces at a uniform distance from said heating means. A blow-torch is used for applying intense heat to a tooth, and by certain apparatus the heating flame is shut off at a predetermined point and then the tooth is immersed and quenched. Patents have already been granted in Great Britain on these machines.

Electric Furnace, *by Herbert W. Strong, of Cleveland Heights, Ohio, assignor to Strong, Carlisle & Hammond Co., of Cleveland. 1,762,201; June 10.*

The invention relates to electric furnaces as shown in the figure, having a heating chamber *1* surrounded by the usual inner walls *2* of high-grade refractory material. The heating elements or globars *9*, of circular section, are suitably positioned with respect to depressions in the linings which are parallel to the globars, and which are provided with a number of minor depressions having sharp extremities.



These projections are much more quickly brought to incandescence and to a much higher state of incandescence than would otherwise be obtainable. The furnace thus functions with a high degree of efficiency.

Helpful Literature

. . FOR THE ASKING . .

Mayari Steels—Bethlehem Steel Co., has issued a folder on Mayari Nickel-Chromium Steels. These steels possess unusually high fatigue-resistance and endurance, and stand up under severe shocks and dynamic stresses. Ask for bulletin No. B-1.

Testing Machines—Pittsburgh Instrument and Machine Co. New catalog describing Brinell machines and accessories. Also "Diamo-Brinell" type, a direct-reading Brinell tester using either 1 millimeter diamond or 2 millimeter steel ball. Ask for bulletin No. B-2.

Nirosta KA2—Associated Alloy Steel Co. "Information on 18-8 Nirosta KA2." Send for our technical bulletin series on 18-8 Nirosta KA2 covering physical properties, resistance to chemical attack, fabrication, etc. Ask for bulletin No. B-3.

Corrosion and Heat Resisting Steels—Colonial Steel Co., Vanadium Alloys Steel Co., and Anchor Drawn Steel Co. Booklet gives complete data regarding stainless A, stainless B, stainless I, stainless FMS, stainless N, stainless U and stainless CNC. It is intended for shop men to whom it gives valuable technical information. Ask for bulletin No. B-4.

Die Blocks—Heppenstall Co. Booklet of 50 pages on various Heppenstall die blocks. Booklet also contains metallurgical engineering data, tables of weights of materials, temperature conversion, mensuration formulae, etc. Ask for bulletin No. B-5.

Deoxidizers—Vanadium Corp. of America. Leaflet describing Alsifer, a material used for the deoxidation of steel during manufacture. Ask for bulletin No. B-6.

Oil Coolers—Griscom-Russell Co. "Cooling of Quenching Oil in the Heat Treatment of Steel." Outlines heat treatment principles, explains the factors that determine correct quenching speed, discusses applications and limitations of various quenching mediums and explains methods by which many concerns secure uniformly excellent results. Ask for bulletin No. B-7.

Pot Furnaces—Hyro Mfg. Co. Booklet describes new Hyro pot furnaces for case hardening by cyanide and other salts, heat treating, etc. This new furnace makes certain kinds of heat treating safer and more efficient. Ask for bulletin B-8.

Furnaces—American Gas Furnace Co. "Furnaces for Various Heat Treatments," a discussion of the requirements in hardening high speed steel with reference to furnace equipment, also an outline of various heating machines and a description of rotary retort machines for carburizing. Ask for bulletin No. B-9.

Nickel Steel—International Nickel Co. Data and Applications. A series of 17 8½ by 11-inch semi-technical bulletins with convenient loose leaf type binder to facilitate filing and increase their reference value. Ask for bulletin No. B-11.

Heat Treating Chemicals—Roessler and Hasslacher Chemical Co. Booklet "Case Hardening and Heat Treatment of Steel." Comprehensive data on cyanides for surface hardening, physical properties and methods of use of salt baths for drawing, annealing and general hardening. Ask for bulletin No. B-13.

Hardness Testing—Wilson-Maeulen Co. Booklet entitled "Hardness Testing of Metals" 48 pages of statements by users of the Rockwell hardness tester explaining the applications they are making of the Rockwell tester. Ask for bulletin No. B-14.

Polishing Machines—Guthrie-Leitz Grinding and Polishing Machine—E. Leitz, Inc. This Leitz publication illustrates and describes a complete line of Leitz metal microscopes and accessories. They are used extensively in metallographic laboratories and serve for routine and research investigations. Ask for bulletin No. B-15.

Heat Treating Furnaces—W. S. Rockwell Co. Catalog covering Rockwell continuous heat treating furnaces built in great variety of sizes, electric or fuel. Ask for bulletin No. B-16.

Ascoloy 33—Allegheny Steel Co. Technical bulletin describing this remarkable heat resisting alloy will be sent on request. Ask for bulletin No. B-17.

Fuel Fired Furnaces—Electric Furnace Co. Eight-page bulletin illustrating oil and gas fired continuous and batch type billet heating, forging and car type furnaces for heating, normalizing and heat treating, also labor saving material handling equipment. Ask for bulletin No. B-18.

Nirosta Buyers Guide—Krupp Nirosta Co., Inc. A concise listing of Companies producing Nirosta metal, their addresses and the forms of material they are prepared to furnish. Ask for bulletin No. B-19.

Furnaces—Strong, Carlisle and Hammond Co. invites your requests for their bulletins and reprints of recent furnace installations. Your inquiries are solicited. Ask for bulletin No. B-20.

Electric Furnaces—American Electric Furnace Co. A new four-page bulletin fully describing small electric box type furnaces. Ask for bulletin No. B-21.

Nitriding—Hevi Duty Electric Co. has just published a new bulletin "Essentials of Successful Nitriding," giving a description of the elements of successful nitriding given in light of the company's research, in the laboratory and in regular production. Ask for bulletin No. 22.

Potentiometers—Thwing Instrument Co. "The Treasure Chest" is a highly accurate portable potentiometer, a laboratory in itself, completely self contained with standard cell, batteries, resistance coils, self checking feature, stations for checking thermocouples and for reading temperatures from thermocouples. Ask for bulletin No. B-23.

Slushing Compound—The Skybryte Co. Steebrite is an entirely different rust preventing compound from ordinary oils and greases. It has none of their objectionable features and gives greater protection to sheet and strip steel and fabricated parts. Ask for bulletin No. B-24.

(Continued on page 146)

Metal Progress, 7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described under "Helpful Literature for the Asking" in October Metal Progress. (Order by number.)

. . . .

Name . . . .

Position . . . .

Firm . . . .

Address . . . .

Helpful Literature Continued.

Industrial Regulators—Minneapolis-Honeywell Regulator Co. Booklet describing their motorized valves used in furnace temperature regulation. These valves operate with their regulators or with any pyrometric controller to regulate flow of gas, oil and air. Ask for bulletin No. A-2.

Resistance Thermometers—Leeds and Northrup Co. Revised catalog treating in detail resistance thermometers for recording, controlling and indicating temperatures, covering heating and ventilating, applications in refrigeration and chemical plants, gas-making and other low temperature applications. Ask for bulletin No. A-3.

Tool Steels—Carpenter Steel Co. Bulletin illustrating and describing methods for testing the uniformity of tool steel. Discusses uniform hardness penetration, etc. Published by the research department. Ask for bulletin No. A-4.

Steel Refining—Densite Corp. of America. A folder in the form of a chart showing physical properties and photomicrographs of structures and inclusions of various carbon steels refined with Densite. Chart is of especial interest to metallurgists and heat treaters. Ask for bulletin No. A-5.

Gas Heat—American Gas Association. A textbook on the uses of gas in industry, giving comprehensive data on industrial gas heat. Illustrated. Free. Ask for bulletin No. A-7.

Steel Handbook—Jos. T. Ryerson & Sons, Inc. Handbook on Tool and Alloy Steels. Description, technical data and general information on tool and alloy steels. Also nontechnical description of heat treating methods and shop practice applying to various steels. Ask for bulletin No. A-8.

Induction Furnaces—Ajax Electrothermic Corp. This bulletin gives latest information regarding coreless induction furnaces in capacities up to several tons, and motor-generator equipments for energizing furnaces. Ask for bulletin A-9.

Corrosion Prevention—Dearborn Chemical Co. Booklet describing latest scientific methods of treating water for prevention of scale, corrosion and foaming in steam boilers, dealing with related problems in connection with scale and corrosion in other power plant equipment. Ask for bulletin No. A-10.

Heat Resisting Steels—Midvale Co. Booklet is largely a diagrammatic classification showing the content of the various alloys. It was produced because of a large number of requests for exactly this type of information. Ask for bulletin A-11.

Special Analysis Steels—Wheelock, Lovejoy & Co. Folders give analysis Hy-Ten steel ranges in carbon from .10 to 1.00 per cent. There is a Hy-Ten grade for every vital machine part. Ask for bulletin No. A-12.

Tool Steel Handbook—Columbia Tool Steel Co. Booklet contains valuable information concerning the making of tools, heat treating, application of steels, with tables, etc. Ask for bulletin No. A-13.

Heat Resisting Alloys—General Alloys Co. General catalog on Q-Alloys, which has recently been prepared describing many applications of heat resisting alloys. Ask for bulletin No. A-15.

Pickling Equipment—Weaver Bros. Co. Catalog listing equipment and supplies now available. Depicts all necessary equipment and has new "theory and practice of pickling." Ask for bulletin No. A-17.

Stainless Irons—Republic Steel Corp. Series of booklets descriptive of Enduro Stainless Irons. Each booklet is devoted to a single type of stainless and contains complete fabrication data, and descriptions of the physical and chemical properties. Ask for bulletin No. A-19.

Springs—Wallace Barnes Co. "The Mainspring" issued monthly giving to spring users technical information on springs, their design, manufacture and use. Contains helpful charts, formulas and information as to spring materials and their manufacture. Ask for bulletin No. B-10.

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The Engineering Index

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In the preparation of the Engineering Index by the staff of the American Society of Mechanical Engineers some 1700 domestic and foreign technical publications received by the Engineering Societies Library (New York) are regularly searched for articles giving the results of the world's most recent engineering and scientific research, thought, and experience. From this wealth of material the A. S. S. T. is supplied with this selective index to those articles which deal particularly with steel treating and related subjects.

AIRPLANE MANUFACURE

METAL CONSTRUCTION. Metal Aircraft Production. *Automobile Engr. (Lond.)*, vol. 20, no. 269, July 1930, pp. 245-248, 12 figs.

Manufacturing operations and equipment at Works of Boulton and Paul, Ltd.

WELDING. Procedure Control for Aircraft Welding, H. L. Whittemore, J. J. Crowe and H. H. Moss. *Welding*, vol. 1, no. 9, July 1930, pp. 589-590 and 595, 3 figs.

Discussion of specifications for material and apparatus used; ability of operator; technique used in each operation; inspection of finished product; brief abstracts of Procedure Control for Welding Aircraft Joints—Report by Committee of American Bureau of Welding.

ALLOY STEEL

TITANIUM CONTENT. Influence of Titanium on Transformation Points of Steel (Influence du titane sur les points de transformation de l'acier), A. Michel and P. Benazet. *Revue de Métallurgie (Paris)*, vol. 27, no. 6, June 1930, pp. 326-333, 22 figs.

Results of study made with Chévenard differential dilatometer, with Pyros gage, and with Saladin-le Chatelier thermal-analysis apparatus on ordinary extra-mild steel and on extra-mild inoxidizable steel with 13 per cent chromium.

ALLOYS

ELECTRIC RESISTANCE. Report of Committee B-4 on High-Temperature and Electrical-Resistance Alloys. *Am. Soc. Testing Matls.—Proc.*, part 1, vol. 29, 1929, pp. 245-251.

Recommendations affecting standards and tentative standards.

ALUMINUM

Aluminum Now Competes with Copper, Steel and Other Products, R. J. Anderson. *Iron Age*, vol. 126, no. 5, July 31, 1930, pp. 284-288, 6 figs.

Survey of application of aluminum in various parts of industry; notes on physical properties and advantages of aluminum as compared with other materials.

STRUCTURAL USES. Exemplary Adaptation of Aluminum to Construction, J. D. Edwards. *Chem. and Met. Eng.*, vol. 37, no. 7, July 1930, pp. 428-429, 2 figs.

Aluminum Research Laboratories' new home at New Kensington, Pa., represents adaptation of material to tasking variety of needs; door hardware of aluminum; lighting fixtures; aluminum pipe; use of aluminum for storage and distribution of distilled water; for radiators and paint.

ALUMINUM ALLOYS

CORROSION. Change of Mechanical Properties Under Effect of Corrosion (Diminution des propriètes mècaniques sous l'effet de la corrosion), Cournot and Molnar. *Revue de Mètallurgie (Paris)*, vol. 27, no. 6, June 1930, p. 290.

Results of tension tests to determine influence of corrosion on mechanical properties of special anti-corrosive alloys without copper; of alloy containing 4.3 copper and additions of manganese, silicon and magnesium; and of duralumin.

CORROSION. Method of Electromotive Forces of Dissolution (Mèthode des forces electromotrices de dissolution), *Aubert and Prot. Rèvue de Mètallurgie (Paris)*, vol. 27, no. 6, June 1930, pp. 296-299, 1 fig.

Conclusions concerning seawater corrosion of certain light alloys based on 1928 research.

CORROSION. Control Methods and Study of Mechanism of Corrosion (Methodes de controle et ètude du mècanisme de la corrosion), E. Herzog and G. Chaudron. *Revue de Mètallurgie (Paris)*, vol. 27, no. 6, June 1930, pp. 285-289.

Critical study of corrosion tests of light alloys with aluminum base in presence of seawater.

TESTING. Flow Tests Under Constant Pressure of Aluminum and Alpax (Essais de coulabilité, sous prossion constante, de l'aluminum et de l'alpax), A. Courty. *Acadèmie des Sciences—Comptes Rendus (Paris)*, vol. 190, no. 15, Apr. 14, 1930, pp. 936-938.

Pressure of molten metal is kept constant by flap-valve arrangement in form of thin lead sheet; values obtained by this method check well; refinement with alkali, repeated fusions, duration of heating and overheating have only insignificant influence upon fluidity of alpax, in contrast to their influence upon its mechanical properties.

ALUMINUM CORROSION

Passivity Phenomena of Aluminum Resting in Very Diluted Acids and Lyes (Ueber Passivitaetserscheinungen an Aluminum in ruhenden, sehr verduennten Saeuren und Laugen), L. W. Haase. *Hauszeitschrift der V.A.W. u.d. Ertwerk A.G. fuer Aluminium (Berlin)*, vol. 2, no. 2, May 1930, pp. 54-60, 5 figs.

Discussion of chemical equilibria pertaining to corrosion theory; test shows that purity of aluminum is essential factor in forming protective coating to prevent further corrosion.

(Continued on page 168)

Unusual Corrosion of Aluminum by Alkali, O. W. Storey. *Am. Electrochem. Soc.—Preprint*, no. 58-4, for mtg. Sept. 25-27, 1930, pp. 43-48, 4 figs.

Peculiar case of pitting of aluminum electric-oven walls was investigated; corrosion of aluminum was found to be caused by caustic soda of sodium silicate adhesive used for built-up asbestos insulation, in presence of an excessive amount of moisture in the atmosphere.

Use of Aluminum in Chemistry (Die Verwendung des Aluminiums in der Chemie), P. Drossbach. *Hauszeitschrift der V.A.W. u.d. Erftwerk A.G. fuer Aluminium (Berlin)*, vol. 2, no. 2, May 1930, pp. 39-41.

Review of electrochemical characteristics of aluminum with respect to corrosive process; tables give data on reaction of aluminum with inorganic and organic compounds.

Short Method for Complete Analysis of Magnesium-Aluminum Alloys, S. S. Singer. *Indus. and Eng. Chem.*, vol. 2, no. 3, July 15, 1930, p. 288.

Method of procedure explained based upon fact that iron and aluminum will not be precipitated by sodium ammonium phosphate in presence of tartaric acid, while magnesium will be precipitated completely and quantitatively as a stable magnesium ammonium phosphate.

BEARING METALS

BABBITTING. Babbitting Plant for Bearings, G. A. Gibbs. *Machy. (Lond.)*, vol. 36, no. 928, July 24, 1930, pp. 529-531, 5 figs.

Description of design and operation of tools in plant for preheating, tinning and chilling of bearings; sketches show sectional view of filling machine and details of half bearings poured horizontally.

STANDARDS. Ball and Roller Bearings—Wide Type. *Am. Standards Assn.—Am. Standard and Recommended Practice*, Apr. 15, 1930, pp. 1-8.

Approved American standard covering single row type of angular ball bearing and wide type of ball and roller bearings.

BOILER MANUFACTURE

WELDING. What's New in Plant Equipment. *Power*, vol. 72, no. 3, July 15, 1930, pp. 112-115, 9 figs.

Tests run at Hedges-Walsh-Weidner plant of Combustion Engineering Corporation, where pressures up to 3450 lb. per sq. in. were reached without rupture of welded boiler shell.

WELDING. Arc-Welded Boilers Not Far Off. *Elec. World*, vol. 96, no. 7, Aug. 16, 1930, p. 306.

Boiler manufacturers are turning eager eyes toward arc-welding processes used in construction of similar vessels, such as oil cracking stills, which have long been made for higher pressures and temperatures than are common in boilers; vessels with 6 in. walls have been made by arc welding and no service failure has developed; arc-welding speeds compared.

CAST IRON

ALLOY. High-Quality Cast Iron in Modern Engineering Practice, A. B. Everest. *Engineering (Lond.)*, vol. 130, no. 3365, July 11, 1930, pp. 56-58, 6 figs.

Brief survey of use of alloy additions in cast iron, it is seen that wherever high strength and good wearing qualities, together with improved machinability are desired, there are strong grounds for increased application of alloy iron, and use of special elements enables foundrymen to give engineer more uniform and more reliable product with improved life and service. Paper read before Rugby Engineering Society, Jan. 15, 1930.

Gray Iron Possesses Valuable Engineering Properties. *Foundry*, vol. 58, no. 15, Aug. 1, 1930, pp. 110-113, 10 figs.

Discussion of practice controlling strength of cast iron and effect of percentage of principal constituents as purchased; diagram present test results of various authorities.

(Continued on page 170)

CHROMIUM STEEL

New Chromium Steel Contains Zirconium Sulphide, F. R. Palmer. *Steel*, vol. 87, no. 4, July 24, 1930, pp. 50, 52, and 54, 7 figs.

Description of manufacture, composition, and properties of steel made by Carpenter Steel Co., Reading, Pa.; typical applications are illustrated.

Determination of Chromium in Special Steels (Die Bestimmung des Chroms in Sonderstaehlen), E. Schiffer and P. Klinger. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 4, no. 1, July 1930, pp. 7-15.

Critical examination of different practical methods; study of influence of usual alloying elements; method recommended for pure chromium steels with low carbon content, for steels with high chromium and carbon content, chromium steels with nickel, cobalt, vanadium, or tungsten, and with other elements.

CHROMIUM-NICKEL STEEL

Pitfalls to Avoid in Drawing High Chrome-Nickel Alloy Steel, C. C. Snyder. *Iron Age*, vol. 126, no. 5, July 31, 1930, pp. 292-294, 2 figs.

Discussion of characteristics and properties of chrome-nickel steel; data on heat treating and several pickling methods are given.

Skyscraper Employs 300 Tons of Corrosion-Resisting Steel, E. F. Ross. *Steel*, vol. 87, no. 6, Aug. 7, 1930, pp. 43-46 and 50, 12 figs.

Outline of treatment of chromium nickel steel used for window trim, cap, roofing, and other decorative purposes on new Empire State Building in New York; notes on handling and assembling.

POLISHING. Polishing Chrome—Nickel-Alloy Steel Requires Care and Special Compounds, C. C. Snyder. *Iron Age*, vol. 126, no. 6, Aug. 7, 1930, pp. 353-356, 3 figs.

Discussion of methods for grinding and polishing chrome-nickel-steel; notes on abrasive materials and their use; table gives tests made to remove cement and plaster adhesions.

POLISHING. New Plant Can Polish 30 Tons of Chrome-Nickel Sheets Daily, E. F. Ross. *Steel*, vol. 87, no. 4, July 24, 1930, pp. 43-45 and 58, 4 figs.

Description of polishing methods and equipment of Republic Steel Corp., Massillon, Ohio; notes on handling and pickling of sheets.

DIES

BLANKING. Chart for Determining Blanking Pressures for Mild Steel. *Machy. (Lond.)*, vol. 36, no. 926, July 10, 1930, p. 473.

Logarithmic chart based on assumption that material has shearing strength of 50,000 lb. per sq. in. and that blanking die has no shear; formulas for computing data are explained.

ELECTRIC FURNACES

Electric Tapping and Melting Furnaces (Hornos eléctricos de colada y fusion), R. Gross. *Ingenieria y Construccion (Madrid)*, vol. 8, no. 89, May 1930, pp. 240-244, 13 figs.

Engineer of electrochemical section of Siemens & Halske organization describes and discusses various types of furnaces; three-phase direct voltaic arc; low frequency induction; high frequency modern furnace.

Is Electric Heat Economical? W. S. Scott. *Elec. World*, vol. 96, no. 5, Aug. 2, 1930, pp. 213-215.

Reasons for adoption of electric furnaces were that those devices accomplished results not obtainable with former methods, and in final analysis proved more economical; actual book values from users of electricity are given.

OPERATION. A User's Viewpoint on the Electric Furnace, F. A. Melmoth, *Elec. World*, vol. 96, no. 3, July 19, 1930, pp. 128-130.

Appreciation of virtues and value of electric furnace in steel casting foundry is discussed; notes on scrap steel in electric furnace; performance is dependent on continuity of use.

(Continued on page 172)

ELECTRIC WELDING

ARC. Development in Arc Welding Methods. *Can. Engr. (Lond.)*, vol. 59, no. 4, July 22, 1930, pp. 169-170.

General discussion of latest developments in equipment and methods; arc welding in construction of buildings, bridges and machinery; large buildings erected by welding process; summary of advantages for building and machinery construction.

RESISTANCE. Fusion Welding as Applied to Railroad Work, F. Longo. *Am. Welding Soc.—Jl.*, vol. 9, no. 7, July 1930, pp. 82-86.

Divisions of resistance welding and definitions; substitution of resistance welding in place of rivets or screws; advantages of spot welding given, requires little floor space, fewer operations, eliminates noise; general outline of equipment and application.

ELECTRIC WELDING MACHINES Methods and Machines for Resistance Welding, R. T. Gillette. *Am. Machinist*, vol. 73, no. 5, July 31, 1930, pp. 193-195, 7 figs.

Outline of various types of resistance welding such as, spot, projection, line, butt, resistance annealing, flash, and resistance soldering and brazing; design and functioning of welding machines for different purposes discussed.

WELDING. Electric Locomotives with Welded Frame and Trucks (Elektrische Lokomotive mit geschweissten Rahmen und Drehgestellen), W. Reichel. *V. D. I. Zeit. (Berlin)*, vol. 74, no. 23, June 7, 1930, pp. 767-768, 5 figs.

Brief description of welded frame construction used for electric locomotives with individual axle drive; outline of principal types of locomotives built by Siemens Schuckert.

FURNACES

HEAT TREATING. The Heat Treatment of Motorcycle Parts. *Fuels and Furnaces*, vol. 8, no. 8, Aug. 1930, pp. 1041-1044, 2 figs.

Various types of furnaces used in heat treatment of motorcycle parts, including batch type carburizing furnace, continuous automatic furnace used interchangeably for various kinds of heat treating, periodic furnaces for miscellaneous work, lead pots, cyanide pots, and rotary type hardening furnace.

METALLURGICAL. Influence of Furnace Design on Metallurgical Reactions (Ueber den Einfluss der Ofengestaltung auf metallurgische Umsetzungen), E. J. Kohlmeyer. *Metall und Erz (Berlin)*, vol. 27, no. 1, 1st Jan. issue, 1930, pp. 1-9 and (discussion) 9-10, 8 figs.

Importance of accelerating reaction of metallurgical processes; difficulty of intensification with endothermal processes; dezincifying processes; details of rotary furnace which serves to intensify refining process and reduction of metal oxides.

(Continued on page 174)

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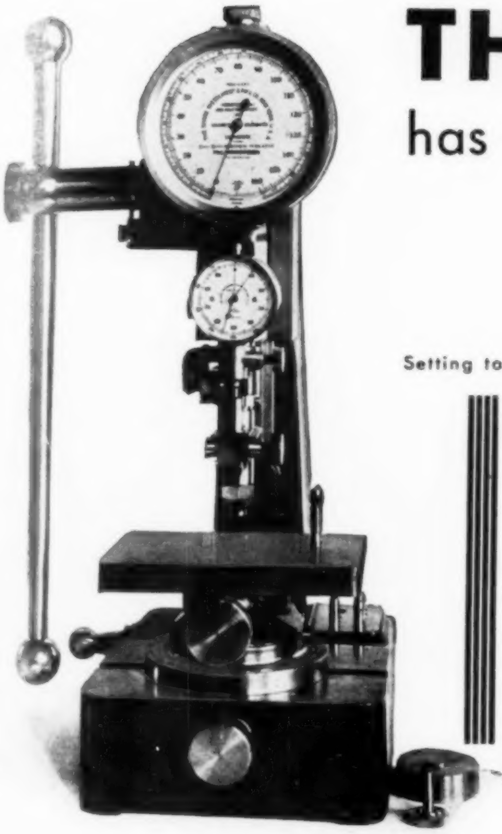

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HEAT INSULATING MATERIAL

CONDUCTIVITY. Determination of Heat Conductivity Coefficient of Plate-Shaped Bodies (Ein Beitrag zur Bestimmung der Waermeleitzahl plattenfoermiger Koerper), S. Gelius. *Gesundheits-Ingenieur (Munich)*, vol. 53 (Special Number), June 4, 1930, pp. 10-17, 6 figs.

Report from laboratory of engineering physics of Munich Institute of Technology presenting experimental and mathematical data on relative and absolute precision of measurements by apparatus of various designs for determination of heat conductivity of insulating plates. Appendix by W. Koch, describes temperature regulation of the cooling water.

FLOW OF HEAT. Transient Flow of Heat Through Insulation, A. R. Stevenson, Jr. and H. L. Bojer. *Refrig. Eng.*, vol. 20, no. 1, July 1930, pp. 23-29, 5 figs.

Theoretical mathematical analysis of heat flow with special application to variation of temperature in refrigerators; tests on transient heat flow; test with box cooled by refrigerating unit; equation for transient temperature when refrigeration is shut off.

HIGH SPEED STEEL

Report of Research Committee on the Effect of Tin and Arsenic on High-Speed Tool Steel. *Am. Soc. for Testing Matls.—Proc.*, part 1, vol. 29, 1929, pp. 167-171.

Article indexed in Engineering Index 1929, p. 928, from preprint from Proc. part 1.

Influence of Nickel and Manganese on Properties of High-Speed Steel (Ueber den Einfluss von Nickel und Mangan auf die Eigenschaften von Schnelldrehstahl), V. Ehmcke. *Archiv fuer das Eisenhuettenwesen (Duesseldorf)*, vol. 4, no. 1, July 1930, pp. 23-35, 21 figs.; see also brief abstract in *Stahl u. Eisen*, vol. 50, no. 32, Aug. 7, 1930, pp. 1131-1132, 21 figs.

Contribution to solution of annealing phenomena in high-speed steel and its adaptability as heat-resisting steel; results of hardening and annealing tests; dilatometric tests; influence of nickel and manganese additions.

IRON-CHROMIUM ALLOYS

A Study of the Iron-Chromium-Carbon Constitutional Diagram, V. N. Krivobok and M. A. Grossmann. *Am. Soc. for Steel Treating—Trans.*, vol. 18, no. 1, July 1930, pp. 1-38, 55 figs.

Relationships when chromium content is varied from zero up to about 18 per cent; in absence of carbon, increase in chromium caused region of delta iron to merge with alpha region, eliminating gamma iron when chromium was above 14 per cent; in presence of carbon, range of temperature and carbon content in which austenite was associated with delta iron merged with range in which austenite was associated with alpha iron.

(*Continued on page 176*)

IRON AND STEEL

ELECTRIC PROPERTIES. Iron and Steel Used in Electrical Engineering, L. E. Benson. *Elecn. (Lond.)*, vol. 105, no. 2719, July 11, 1930, pp. 51-54, 10 figs.

Cast materials, grey cast iron, malleable iron, steel castings, and fabricated parts; tables showing properties of various engineering materials, composition and properties of cast and malleable irons and physical test figures for high quality cast steel flywheel.

PROTECTIVE COATINGS. Protective Coatings for Iron and Steel, H. N. Bassett. *Indus. Chemist*, vol. 6, no. 66, July, 1930, pp. 293-6.

Use of paints and similar media which are generally applied by means of brush or air spray.

METALS

RECRYSTALLIZATION. Atomic Principles of Recrystallization (Atomistische Grundlagen der Rekristallisation), U. Dehlinger. *Zeit. fuer Metallkunde (Berlin)*, vol. 22, no. 7, July 1930, pp. 221-223 and (discussion) 227-229, 7 figs.

Author deals with recrystallization in degrees of deformation, which results in total destruction of textures of material; experimental measurements of velocity of recrystallization; with aid of so-called hooking, that is joining together of adjacent areas which are in equilibrium, this velocity is indicated.

MOLYBDENUM STEEL

Molybdenum in High-Speed Steel, S. B. Ritchie. *Army Ordnance*, vol. 11, no. 61, July-Aug. 1930, pp. 12-19, 12 figs.

Investigation as to practicability of eliminating tungsten wholly or in part from high speed steels undertaking at Watertown Arsenal; comparative test of molybdenum steel with tungsten steel; methods of heat treating; it was determined that there are no difficulties in manufacture of molybdenum high-speed steel in desired quantities.

On the Lowering of Critical Points in Molybdenum Steels, T. Murakami and T. Takei. *Chem. News (Lond.)*, vol. 141, no. 3665, July 11, 1930, p. 21.

Cause of stepped lowering of critical points and formation of acicular ferrite were satisfactorily explained, assuming rate of crystallization curves for respective constituents, ferrite, carbide and martensite. Paper read before World Eng. Congress, 1929, Tokyo.

OPEN-HEARTH FURNACE

SLAG CONTROL. Slag Control Essential, F. W. Sundblad. *Iron Age*, vol. 126, no. 5, July 31, 1930, pp. 289 and 314-315.

Brief discussion of fundamental principles of open hearth operation in mass production of steel; character and effect of slag is discussed; notes on relationship between slag and metal.

STAINLESS STEEL

Classification of Corrosion Resisting Steels, H. N. Booker, *Paper Industry*, vol. 12, no. 5, July 1930, pp. 849-851, 1 fig.

Properties of stainless iron, stainless steel, high chromium alloy and chromium-nickel steel.

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